dataTaker®

Intelligent Data Logging Products

DT80 Range

DT80/81/82/85
Series 1, 2 & 3
Includes CEM20

User's Manual

A complete guide to:

- **data acquisition**
- **data logging**
- **programming**
- **sensor wiring**
- **communications**

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DT80 Range User's Manual

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UM-0085-B3

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Related Software Products

dEX, DeTransfer, DeLoad, *dataTaker* ActiveX, *dataTaker* LabVIEW™ instrument driver

Important: Firmware Version Covered in This Manual

This version of the *dataTaker DT80 Range User's Manual* (UM-0085-B3) applies to the *DT80* range of data loggers (DT80, DT80G, DT80L, DT80GL, DT81, DT82E, DT82I, DT85, DT85G, DT85L and DT85GL, Series 1, 2 and 3) running **Version 8.08** firmware.

WARNING

dataTaker products are not authorized for use as critical components in any life support system where failure of the product is likely to affect the system's safety or effectiveness.

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Part A – The *DT80*

Figure 1: The dataTaker DT80G, DT80 and DT81 (rear), DT85G and DT85 (centre), DT82E and CEM20 (front)

DT80 *Concepts*

What is the *DT80*?

The *dataTaker DT80* range of data acquisition and logging instruments are tools to measure and record a wide variety of quantities and values in the real world.

The web based *dEX* graphical user interface makes it quick and easy to define basic measurement tasks. Logged data can then be easily extracted via a USB "memory stick", or downloaded using the web interface into files ready for import into spreadsheets and data analysis tools.

The *DT80* range of loggers also include a powerful programming language which allows complex systems to be developed and monitored.

Extensive sensor support and communications options, and a rugged and low-power design, make the *DT80* a very flexible data logger.

The *DT80* Product Family

Models

The *DT80* product family includes the following models:

- The **DT80** is a full-featured data logger,
- The **DT81** is a single channel variant of the DT80.
- The **DT82E** is a low cost, low power logger designed for environmental applications.
- The **DT82I** is designed for industrial applications.
- The **DT85** is an expanded and enhanced version of the DT80.
- The **DT80L** and **DT85L** are low power variants of the DT80 and DT85
- The **DT80G** and **DT85G** ***GeoLoggers*** are designed for Geotechnical applications.
- The **DT80GL** and **DT85GL** are low power variants of the DT80G and DT85G
- The **CEM20** (Channel Expansion Module) is a 20-channel analog multiplexer which can be used to expand the number of analog input channels on a DT80 or DT85.

All of these models operate in a similar way; the differences are mainly to do with the number of input channels and other hardware features.

Table 1 *(P14)* lists the main differences between each model.

Series 1, 2 and 3

In January 2008, the original DT80, DT81 and DT85 models were superseded by enhanced **Series 2** models. These offered an all-new web based interface (**dEX**), additional power outputs, and more flexible analog input switching.

Series 3 models were introduced from October 2010. These supersede Series 2 and include enhanced resistance measurement options and an isolated switched 5V power output.

Series 2 and 3 units are clearly labelled as such on the front panel.

When a logger model number is displayed, the series is shown as a suffix, e.g. "DT85L-3" is a Series 3 DT85L.

GeoLoggers

The DT80G/GL and DT85G/GL "GeoLoggers" are equivalent to the DT80 and DT85, but also include direct support for **vibrating wire strain gauges**, which are widely used in geotechnical applications; see *Strain Gauges – Vibrating Wire* *(P255)*. Throughout this manual, references to the DT80 and DT85 also refer to the DT80G and DT85G respectively, unless otherwise noted.

Low Power Models

Most *DT80* models include an internal 6V lead acid battery. However the low power "L" and "E" models do not include an internal battery and are instead optimised for operation with an external battery (often solar charged). Throughout this manual, references to the DT80 and DT85 also refer to the DT80L and DT85L respectively, unless otherwise noted.

Channel Expansion Module

The CEM20 is an analog multiplexer designed to work with a DT80 or DT85 Series 2 logger. It provides an easy way to expand the number of input channels. Up to 15 CEM20 modules can be connected to a DT85, giving a total of 300 input channels. See *The CEM20* *(P302)*.

Note: In this manual, the term *DT80* (italics) is used to refer to all products (DT80, DT81, DT82 and DT85; Series 1, 2 and 3). If a feature or behaviour is specific to a particular model, this will be made clear in the text.

Feature	DT81-1	DT80-1	DT85-1	DT81-2	DT82E-2	DT82I-2	DT80-2	DT80G-2	DT85-2	DT85G-2	DT82E-3	DT82I-3	DT80-3	DT80G-3	DT80L-3	DT80GL-3	DT85-3	DT85G-3	DT85L-3	DT85GL-3
Analog input channels	1	5	16	1	2	2	5	5	16	16	2	2	5	5	5	5	16	16	16	16
Fully isolated analog input pairs (+- and *# terminals switched independently)	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2-wire resistance measurements on *#, +# and -# terminal pairs	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vibrating wire strain gauge support	-	-	-	-	-	-	-	✓	-	✓	-	-	-	✓	-	✓	-	✓	-	✓
CEM20 support	-	-	-	-	-	-	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Digital I/O channels (open-drain outputs)	3	4	4	3	3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4
Digital I/O channels (logic outputs / SDI-12)	1	4	4	1	1	-	4	4	4	4	1	-	4	4	4	4	4	4	4	4
High speed counter inputs	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	7	4	7	4
Phase encoder inputs	1	2	2	1	-	2	2	2	2	2	-	2	2	2	2	2	3	2	3	2
RS232/422/485 communications port	-	✓	✓	-	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓
RS232 communications port	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
USB communications port	✓	✓	✓	✓	-	-	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Ethernet port	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
USB memory device port	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Switched 12V power output	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Unswitched external power output	-	-	✓	-	-	-	-	-	✓	✓	-	-	-	-	-	-	✓	✓	✓	✓
Switched isolated 5V power output	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Battery charger for internal/external battery	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	-	✓	✓	✓	-	-	✓	✓	-	-
Internal battery (capacity in Ah)	1.2	1.2	4.0	1.2	-	1.2	1.2	-	4.0	4.0	-	1.2	1.2	-	-	-	4.0	4.0	-	-
Modbus master function	-	✓	✓	-	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓
LCD display & keypad	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Status LEDs	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Classic web interface (HTML)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
dEX Enhanced web interface (Flash)	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 1: Feature listing for DT80 Range data logger models

DT80-Friendly Software

Programming and Configuration

There are three main ways to set up and program the *DT80*.

- ***dEX*** is a web based application for programming and monitoring *DT80* Series 2/3 data loggers. *dEX* is built into the logger (no installation required) and runs in your web browser. It provides a totally graphical interface, which means that knowledge of the *dataTaker* programming language is not required. Channels and schedules are defined simply by clicking on icons and making selections from menus and dialog boxes; *dEX* will then generate the required *DT80* program and load it onto the logger.
- Alternatively, commands entered interactively and then sent to the *DT80* via one of its comms ports or a TCP/IP network. This allows full access to the *DT80*'s capabilities. ***DeTransfer,*** or the enhanced web interface's command window, are the best tools for the job here. They both have separate send and receive windows, a macro facility, and many other useful features. A standard terminal program (e.g. *HyperTerminal*) can also be used.
- Finally, you can develop a *DT80* program off-line (e.g. using a text editor), then transfer it to the *DT80* using a USB memory device or send it as a file using *DeTransfer*. ***DeLoad*** is a Windows based application which allows a pre-written program to be transferred to the logger using a simple "drag and drop" operation.

Viewing Data and Status

Once the *DT80* has been set up, there are a number of options for retrieving data and monitoring status:

- The *DT80*'s inbuilt **web interface (*dEX*)** provides a convenient way to access current data values and status information from any web browser. *dEX* is available on all Series 2 or 3 loggers.
- A simple HTML-based web interface is also provided on all loggers. This can be customised if required to provide an application-specific user interface. This interface is designed to operate efficiently on slow communications networks or on portable devices with a small display screen.
- ***DeTransfer*** can be used to view real-time and logged data in text format.
- ***DeLoad*** provides an easy way of collecting logged data, which can then be saved or sent by email.
- ***dataTaker* Instrument driver for LabVIEW™** is a set of drivers and documentation which allows *dataTaker* data loggers to be incorporated in a LabVIEW environment. LabVIEW is National Instruments' industry-leading graphical software development environment for measurement and automation applications.

All software is provided on the CD supplied with your *DT80*, and updates are available from the Datataker website, www.datataker.com (Support/Downloads section).

About This Manual

This manual is intended for all users of the *DT80*. It describes:

- how to connect sensors and other devices to the *DT80*'s input and output channels.
- how to program the *DT80* to collect and return data as required.
- how to manage the data that the *DT80* collects.

The main focus of this manual will be on directly programming the *DT80* using its command language. However, most of the concepts discussed here also apply when building programs using tools such as *dEX*.

A Tour of the *DT80*'s Interfaces

The *DT80*'s interfaces with the outside world are grouped into three main areas: user interface (top), sensor interface (front) and communications interface (side). See also *Inputs and Outputs* (P215).

User Interface

On the top panel of the *DT80* you will find controls which allow the user to interact with the unit during operation – without requiring a host computer:

- A 2-line LCD display shows status messages, measured values, and a menu of pre-defined functions (not DT81)
- Six keypad buttons allow the user to navigate between the various displayed options (not DT81)
- Four status LEDs are provided – the blue **Sample** LED flashes each time a measurement is taken, the green **Disk** LED indicates internal flash disk activity, the red **Attn** LED indicates various warning conditions, and the green **Power** LED flashes at 3 second intervals while the logger is powered and not in low "sleep" mode. The duty cycle of the flash indicates whether the logger is externally powered (long flashes) or running from its internal battery (short flashes). (Note that the **Power** LED is not present on DT80 Series 1.)
- A USB socket allows connection of a USB memory device, which provides a convenient way to retrieve data from the *DT80* (or load a program onto it)

Sensor Interface

On the sloping front panel of the *DT80* there are two rows of terminal blocks – digital channels on the left, analog channels on the right. The green terminal blocks can be quickly unplugged from the *DT80* without unscrewing the sensor cabling.

This interface includes:

- 8 digital input/output/counter channels (**1D** – **8D**), 4 of which are SDI-12 compatible (DT82I: 4 channels; DT81/82E: 4 channels, one of which is SDI-12 compatible)
- an input to wake the *DT80* from low power "sleep" mode (**WK**)
- 4 high speed counter inputs (7 on DT85/85L Series 3) (**1C** – **4C**)
- 2 phase encoder inputs, shared with the counter inputs connected) (**1PE** – **2PE**) (one phase encoder input on DT81, none on DT82E, 3 on DT85/85L Series 3)
- a pair of voltage free relay contact outputs (**RELAY A** and **B**)
- a general purpose switched 12V 150mA power output (**12V**) (DT80/81/82E Series 2/3 and DT85 only)
- a general purpose current limited (300mA) power output (**PWR OUT**), which is derived from the external power input (DT85 only)
- an isolated switched 5V power output (**5V SW**) (Series 3 only)
- digital / power ground terminals (**DGND**)
- an RS232/422/485 compatible serial port (**Tx**, **Rx**, **RTS** and **CTS**) (not present on DT81/82E)
- a number of analog input channels (5 channels for DT80, 1 channel for DT81, 16 channels for DT85)
- an external excitation input (**EXT ***)
- isolated analog ground terminals (**AGND** on DT80/81, **EXT#** on DT80 Series 2 and DT85)

(Note that early production DT80 models only had 4 analog inputs.)

Communications/Power Interface

On the left side panel you have a variety of connectivity options:

- 10-Base-T Ethernet for connection to a host computer or local area network
- USB for high speed connection to a host computer (not present on DT82E/82I)
- RS232 for connection to host computer or modem
- two alternative DC power connectors – a standard plug-pack socket (DC jack) and a 4-pin terminal block (2-pin for DT82E)

For more details, see *Communications* (P158)

A threaded earth point is also available on both left and right side panels.

Getting Started

Power

Powering the DT80 (P221) discusses the ways to provide power to the *DT80*. The simplest option is to plug in the supplied AC adaptor.

All *DT80* models except the DT82E include an internal 6V lead-acid battery which can power the logger if the main external supply is interrupted.

Important The *DT80* is shipped with its main internal battery disconnected. We recommend the battery is connected as soon as practical so that it can charge from the mains adaptor or other external power source. This is achieved by simply plugging the green power connector, see *Powering the DT80* (P221).

Switch On!

When power is connected, you should observe:

- the LCD backlight switches on (DT80/85), and the green **Power** LED starts flashing
- a brief clicking sound as the unit performs an initial self-calibration
- `DT80 restarted` / `Power loss` is displayed on the LCD
- the front panel LEDs flash a few times then the red **Attn** LED continues to flash.

The *DT80* is warning you that its power has been interrupted. Press any of the front panel keys (or send the command **CATTN**) to clear this indication. The **Attn** LED should stop flashing and the display should now read: `DT80 V8.08` / `No current job`. This indicates that:

- the version of *DT80* firmware in use is "8.08" (this number may vary), and
- no user program (or "job") has been loaded

The *DT80* is now idle and waiting for instructions.

Connecting to a Host Computer

In order to program the *DT80*, it is generally necessary to connect it to a "host" computer. The easiest option here is to use the supplied USB cable, or, for the DT82E/82I, the supplied Ethernet cable. Other options are to use a "null-modem" (cross-over) RS232 cable, or to connect the logger to an Ethernet network. See *Communications* *(P158)* for more details of the different communications options.

Very briefly, connecting the *DT80* via USB involves the following steps:

1. Install the supplied ***DtUsb*** driver software. This allows you to access to DT80's network services via a USB connection.
2. Connect the USB cable between the DT80 and the PC.
3. The Windows "New Hardware Found" wizard will then run automatically (if required) to complete the installation of the necessary drivers.
4. Your default web browser will then be launched automatically and the dEX home page will be displayed.

To connect to the *DT80* using Ethernet:

1. Connect the Ethernet cable between the *DT80* and the PC, or between the *DT80* and a socket on your computer's local area network.
2. Use the *DT80* keypad to scroll down to the "Ethernet" screen. Check that a valid IP address is displayed, e.g. 169.254.3.202
3. Launch your web browser and type the logger's IP address into the address bar. The *dEX* home page should be displayed.

The above is only an brief overview. See *USB Port* *(P162)* or *Ethernet Communications* *(P179)* for detailed, step by step instructions.

As an alternative to the *dEX* web-based interface, you can also install the supplied *DeTransfer* software, which can be used to send the text-based commands described in this manual to the logger. *DeTransfer* can operate over a direct RS2323/USB connection or a network connection, and will work with Series 1 or Series 2 loggers.

The remainder of this manual will assume you have successfully established a connection between the host PC and the *DT80*.

Sending Commands

The *DT80* is programmed by sending it textual **commands**. These commands may be either:

- manually entered (using *DeTransfer*, or the Command screen in *dEX*), or
- generated by the *dEX* configuration builder, based on details entered using its graphical user interface controls.

Commands are executed by the *DT80* only after it receives a carriage-return character (↵).

Commands are not case-sensitive; that is, they may be entered using either uppercase or lowercase characters.

In this manual all commands are shown in **`UPPERCASE`**. Responses from the *DT80* are shown `like this`.

After receiving a command, the *DT80* will normally **echo** the command, after converting it to uppercase. Note that the *DT80* does not echo each character as it is received.

After a command has been processed, the *DT80* will normally indicate that it is ready for the next one by transmitting a **prompt** string, such as:

```
DT80>
```

(Command echo and the prompt string can be turned off if required using the **`/e`** switch command, see *Switches* *(P203)*.)

The maximum length of a command is 255 characters.

The general categories of commands are:

- **channel definitions** *(P28)* (e.g. **`2TK("Kiln temp",FF4)`**) – these define what measurements are to be taken, how they are to be acquired and how the measured values are to be presented.
- **schedule definitions** *(P44)* (e.g. **`RA(DATA:2MB)10S`**) – these define when a set of measurements are to be taken and where the results are to be stored
- **job management commands** *(P58)* (e.g. **`BEGIN`**, **`END`**, **`SHOWPROG`**) – these allow a set of schedule and channel definitions to be grouped into a single program, or "job", which can then be treated as a unit.
- **data management commands** *(P90)* (e.g. **`COPYD`**, **`LISTD`**) – these allow logged data points and alarms to be retrieved, displayed or deleted.
- **configuration commands** *(P200)* (e.g. **`PROFILE`**) – these allow various aspects of the *DT80*'s operation to be adjusted to suit particular requirements.

Jobs (sets of commands) are stored in the *DT80*'s internal file system along with the data they generate. Different jobs can be loaded under manual or program control. In addition, the *DT80* can automatically run a particular job every time it is reset or powered up. See *Startup Job* *(P59)*.

Getting Help

There are several options for getting help with programming the *DT80*:

- The command **HELP** *topic* will display useful summary information on a number of topics. Type **HELP** by itself to display a list of available topics. For example, **HELP COMMANDS** will display a list of *DT80* commands.
- This user manual, firmware release notes and a list of known issues are automatically installed onto the *DT80*'s internal file system each time a firmware upgrade is done. In this way you always have access to up-to-date documentation for the installed firmware version. The easiest way to view these is via the *DT80*'s built-in web interface.
- The Datataker website (www.datataker.com) contains an extensive database of frequently asked questions, code examples, sensor information, application notes, video tutorials and an online forum.

Designing Your Data Logging System

Data acquisition and data logging are orderly processes and should be undertaken in a systematic way. In order to obtain effective information efficiently, do the following:

- Identify the quantities to be measured.
- Select the sensors, considering measurement range, accuracy, stability, ruggedness and cost.
- Select the wiring configuration. For example, resistive sensors can be connected in 2, 3 or 4 wire configuration, while serial sensors can use different electrical standards (RS232/RS485 etc.) and data rates.
- Determine sensor output scaling, that is, the relationship between sensor output voltage/current/resistance/etc. and the actual quantity. For many sensor types this calculation is performed automatically by the *DT80* – all you need to do is specify the appropriate channel type.
- Determine how data is to be processed, for example statistical functions such as max/min or histograms may be required.
- Decide on the sample frequency – don't sample faster than you need to.
- Calculate the volume of data to be collected.
- Decide on the method of data recovery and archiving – real-time data return or logging or both? Will logged data be unloaded via a comms port, or collected using a USB memory device, or transmitted to an FTP site? How often?
- Decide on an appropriate communications technology for setup/maintenance and normal operation: RS232, USB, Ethernet, modem, none?
- Consider the power consumption, including the use of low power "sleep" mode. In the event of a power failure will the *DT80*'s internal battery provide adequate running time?

The remainder of this manual will help you address these questions and then generate a suitable program for your *DT80*.

Measurements

What can the *DT80* Measure?

Analog

Using its analog inputs, the *DT80* can directly measure the following:

- **DC voltage** (30mV, 300mV, 3V and 30V ranges)
- **DC current** (0.3mA, 3mA and 30mA ranges)
- **resistance** (10Ω, 100Ω, 1kΩ, 10kΩ ranges)
- **frequency** (0.1 to 10,000 Hz)

Many other quantities can be measured by connecting appropriate **sensors** which convert a physical quantity into something that the *DT80* can measure. The *DT80* directly supports:

- **4-20mA current loop** sensors (0 to 100%)
- **temperature sensors** (thermocouples, RTDs, thermistors, IC sensors)
- **bridges** and **strain gauges**
- **vibrating wire** strain gauges (DT80G/85G only)

This list can be extended by means of user specified scaling calculations.

Digital

The *DT80*'s digital and counter channels allow the measurement of:

- **digital input state** (contact closure or TTL logic)
- **pulse count** (32 bit)
- **phase encoder position** (32 bit)

Serial

Various “smart sensors” can also be read:

- **SDI-12** (Serial Data Interface – 1200 baud) based sensor networks
- other **serial sensor** devices with an RS232/422/485 interface, such as weighing machines, barcode scanners
- **CAN** (Controller Area Network) sensors, using the optional *dataTaker* ***CANgate*** CAN to ASCII gateway device. The use of this product is outside the scope of this manual.

Analog Channels – Introduction

Figure 2: DT80 analog terminals

Input Terminals

The DT80 provides five analog input channels, numbered **1** to **5**. Depending on the wiring configuration used, these allow between 5 and 15 separate voltages to be measured. The DT81 has one analog input channel, allowing 1-3 separate voltages to be measured, and the DT82E has two (2-6 separate voltage measurements). Finally, the DT85 has 16 analog input channels, allowing 16-48 separate voltage measurements.

Each analog input channel on a *DT80* is a 4-wire connection (see *Figure 3*) that allows voltage, current, resistance and frequency to be measured. These are the fundamental signals output by most sensors. It is not necessary to use all four terminals on each channel— two are often adequate.

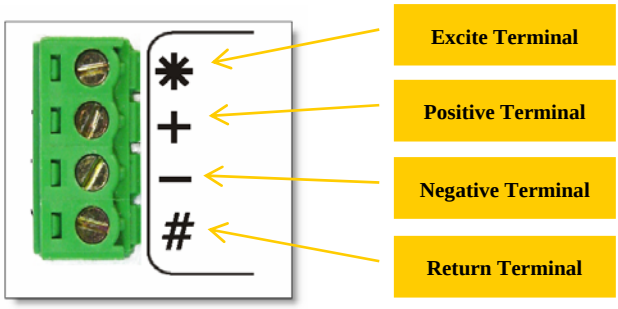


Figure 3: Analog input channel terminal labels

The exact function of each terminal varies depending on how the channel is programmed. In general terms:

- The ***** ("Excite") terminal can be a voltage input (relative to **#** terminal), or it can provide sensor excitation (for example, for resistance measurement) See *Sensor Excitation* (P20).
- The **+** ("Plus") terminal is a voltage input (relative to – or **#** terminal)
- The **–** ("Minus") terminal is a voltage input (relative to **#** terminal)
- The **#** ("Return") terminal is normally used as a common or return terminal. It can also be used as a current input, using the *DT80*'s internal shunt resistor.

Multiplexers

The *DT80*'s analog input channels are **multiplexed**. The required input terminals are first connected to the input of the *DT80*'s instrumentation amplifier and analog to digital converter, then a measurement is taken. The next channel to be sampled is then switched through to the amplifier and ADC, and so on. Simultaneous sampling of analog channels is not possible.

Channel definition commands in the *DT80* program determine which terminals are used for a particular measurement. For example, the channel definition **`1+V`** measures the voltage between the **+** and **#** terminals on channel 1.

Gain Ranges and Attenuators

The *DT80*'s instrumentation amplifier has three switchable gain settings. These give three basic voltage measurement ranges (3V, 300mV and 30mV full scale)

The *DT80*'s default is for its instrumentation amplifier to automatically change gain range to suit the input signal applied to it

by the multiplexers.

If the amplitude of your input signals are known, then the gain can be set manually. Do this by applying the **GL***x* (gain lock) channel option, which disables autoranging for that channel and sets the gain to a fixed range.

The analog inputs also include switchable 10:1 **attenuators**, which effectively provide a fourth range (30V).

Warning Maximum input voltage on any analog input is ±35V dc, relative to the **AGND/EXT#** terminal. If this is exceeded then permanent damage may occur.

Analog Input Configurations

The basic quantity that the *DT80* measures is voltage. Voltages can be measured using two different input configurations:

- **shared-terminal** analog inputs
- **independent** analog inputs

Shared-Terminal Analog Inputs

Sometimes called "single-ended" inputs, a shared-terminal input is one that shares one or more of its terminals with another input. In *Figure 4*, the three sensors share channel 1's **#** terminal. Each of the three inputs is a shared-terminal input.

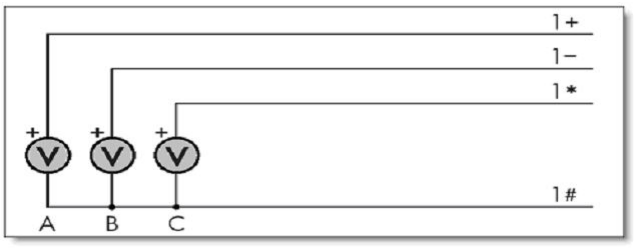


Figure 4 Shared-terminal voltage inputs sharing a channel's # terminal (voltage inputs used as example)

In a shared-terminal configuration, a sensor's "return" or "negative" wire is usually connected to the channel's **#** terminal. The remaining sensor wire (the "positive" or "signal") is connected to any of the channel's other three terminals. The common terminal need not be at ground potential – all voltage measurements (shared or unshared) are **differential**, i.e. only the difference in voltage between the two terminals is reported.

For shared-terminal inputs, the channel number is given a suffix indicating the terminal to which the positive wire is connected. For example, a shared-terminal voltage input applied to channel 1 between the + and # terminals is recognized by the channel definition **1+V**.

Independent Analog Inputs

An independent input (also known as an "unshared" input) is one that connects to its own terminals and does not share any of those terminals with any other inputs. For example, in *Figure 5*, sensor A is connected to channel 1's + and – terminals, and sensor B is connected to the other two terminals of the channel. In other words, each sensor's terminals are independent of the other's — no terminal is used by both sensors.

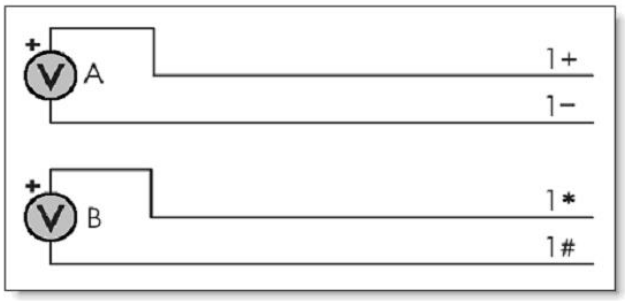


Figure 5 Wiring one or two independent inputs to a single channel (voltage inputs used as example)

Note that each analog input channel can support two independent voltage inputs. In the above example, the channel definition **1V** will read sensor A while **1*V** will read sensor B. The channel definition syntax is fully described in *Channels* *(P28)*

Sensor Excitation

Many sensors require **excitation** (electrical energy) so that they can provide an output signal. For example, to read the temperature of a thermistor, excitation current is passed through the thermistor to generate a voltage drop that can be measured.

The *DT80* can provide

- Voltage source of approx. 4.5V via 1kΩ. Useful for powering some sensors however the supply is not regulated and consequently liable to drift with temperature
- 200µA (approx.) current source. Default excitation for resistance measurement. Very stable over environmental temperature range.

- 2.5mA (approx.) current source. Default excitation for RTD and bridge measurement. Very stable over environmental temperature range.
- User supplied external excitation **EXT*** terminal. The user can provide an external excitation which is appropriate to the sensor being used. (The DT80 Series 2 and DT85 provide two general purpose DC power outputs which may be connected to the **EXT*** terminal to provide external excitation if required.)

See the Excitation category in the *Table 4: DT80 Channel Options* (P43) table.

More Information

For full details on how to connect sensors and make measurements using the *DT80*'s analog inputs, see *Analog Channels* (P233).

Digital Channels – Introduction

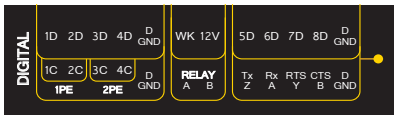


Figure 6: DT80 digital terminals

The *DT80* provides:

- 4 bidirectional digital I/O channels (**1D**-**4D**) with open drain output driver and pull-up resistor (DT81/82E: 3 channels, **1D-3D**)
- 4 bidirectional digital I/O channels (**5D**-**8D**) with tri-stateable output driver and weak pull-down resistor. These channels may also be used for controlling intelligent sensors using the SDI-12 protocol (DT81/82E: 1 channel, **4D**)
- 1 voltage free latching relay contact output (**RELAY**)
- 1 LED output (**Attn**)
- 4 hardware counter inputs (**1C**-**4C**) which can be used as independent counter channels or as two quadrature (phase encoder) inputs (DT81: one phase encoder input, shared with inputs **3C** and **4C**. There are no phase encoder inputs on the DT82E.)

As with analog channels, **channel definition commands** are used to specify which digital inputs are to be measured and/or what digital output states are to be set. For example, the command **1DS** will read the digital state (0 or 1) on channel **1D**, while **3DSO=0** will set channel **3D** low.

A transition on a digital channel can be used to trigger a schedule. This allows a series of measurements to be made (or commands executed) in response to a change in digital state.

The *DT80* can count the number of pulses received on any digital input. The four dedicated counter inputs provide additional capabilities:

- a higher maximum count rate
- the ability to keep counting even if the logger is in low-power "sleep" mode
- optional low-level (5mV) input threshold levels
- optional decoding of phase-encoded input signals

For more details, see *Digital Channels* (P261)

Serial Channels – Introduction

The *DT80* supports two main classes of "smart sensor":

- A wide range of sensors, particularly in the environmental monitoring field, use the **SDI-12** protocol. The *DT80* fully supports this protocol making it a simple process to read measured values. See *SDI-12 Channel* (P272).
- The *DT80* also provides a **generic serial channel**.

The serial channel allows a wide variety of sensors and devices to be controlled and polled. The serial channel:

- can use the dedicated serial sensor port (not DT81/82E), the host RS232 port, and/or the USB port
- supports USB, RS232, RS422 and RS485 signal levels (depending on the port)
- supports point-to-point or multi-drop operation (point-to-point only for the host/USB port)
- features programmable output (poll) strings and a variety of options for parsing returned data
- can trigger execution of a schedule in response to received data

For more details, see *Generic Serial Channel* (P277).

Programming the DT80

Typical Workflow

When creating a program to send to the *DT80*, typically the work will follow this order:

Connect Sensors

Sensors & Channels *(P233)* describes how to measure many different quantities and read many different sensor types using the *DT80*'s analog, digital and serial inputs.

The first step is therefore to refer to the sub-section relating to the quantity you wish to measure. This will help you decide on the most appropriate way to connect the sensor to the *DT80*.

Define Channels

Programming the *DT80* essentially consists of :

- defining a series of measurements to take, and
- specifying when to take them.

Each measurement definition is referred to as a ***channel***. It is important to be clear on how the word "channel" is used – in *DT80* parlance, it refers to a measurement to be made, not a physical input channel.

For example, if you program the *DT80* to measure a voltage on analog input 1, then read the state of digital input 3, then measure the voltage on analog input 1 again then you have defined three channels. The fact that the first and third channels both measure the same physical quantity (the voltage on analog input 1) is irrelevant – as far as the *DT80* is concerned, they are two entirely separate measurements.

To specify when measurements are to be made, channel definitions may be grouped into **schedule** definitions. These specify whether the channels should be sampled immediately, or periodically, or in response to some event.

To define a channel, you need to specify:

- the **input number** (e.g. **1** for analog input 1)
- the **channel type** (e.g. **V** to perform a voltage measurement)
- any **channel options** that may be required (listed in parentheses, e.g. **(GL3V,FF3)**

So to define the three channels mentioned above, you could enter:

```
1V 3DS 1V
```

Since we haven't specified any schedule, these three measurements will be taken immediately, one after the other. Default settings will be used, since no channel options were specified. By default, the *DT80* will then return the measured values in ASCII form to the host computer, e.g.

```
1V 234.9 mV
3DS 1 State
1V 233.0 mV
```

So once you have connected the sensor as described in *Sensors* *(P233)*, you can then test it out by directly entering a suitable channel definition.

For example, suppose we want to check the resistance of a resistor. In the section *Resistance* *(P239)*, several different wiring configurations are given. In this case we are going to connect the resistor directly to the *DT80*'s terminals so we don't need to worry about lead resistance issues. The simplest 2-wire configuration is therefore suitable, as described in *R4 – 2-Wire Independent Resistance Inputs* *(P240)*. We therefore pick an analog input to use, say input 2, and wire the resistor between the * and # terminals on analog input 2. We can now enter the channel definition:

```
DT80>2*R
2*R 559.1 Ohm
```

In this case the channel number is **2*** (analog input 2, measuring between * and # terminals) and the channel type is **R** (measure resistance) and there were no channel options, so the complete channel definition is **2*R**.

Note that a particular physical input can be read using different channel types. For example, a thermocouple can be read as a thermocouple or as a voltage. The command

```
1TK 1V
```

returns both a temperature and a voltage based on two readings of the same sensor.

For more information about how channels (measurements) are specified in the *DT80* programming language, see *Channels* *(P28)*.

Define Measurement Schedules

A **schedule** defines when a set of channels should be measured. It consists of a list of channel definitions preceded by a scan **trigger** specification. See *Schedules* *(P44)*.

As a general rule when creating schedules, don't instruct the *DT80* to read channels more frequently than is really necessary. For example, temperatures generally change slowly so rapid reading does not provide extra useful information.

Up to eleven different schedules can be declared (**A** to **K**), each with a different trigger based on a time interval or a digital input event. The schedule's trigger can be changed at any time, either manually or under program control.

A list of channels without a trigger specification can be entered at any time. These are scanned immediately, without affecting other schedules that may be operating. For more information, see *Immediate Report Schedules* (P51).

Important Whilst a schedule's **trigger** can be changed at any time, its **channel list** cannot be altered without re-entering all schedules. In fact, all schedules must be entered at the same time, either all on one line or between **BEGIN** and **END** keywords (see *Working with Schedules* (P53)).

Jobs

A *DT80* **job** is a logical "hold-all" for a group of schedule definitions and other commands. The command **BEGIN** signifies the start of a job, and the command **END** signifies the end of the job. Once a job has been fully entered, the *DT80* will activate all schedules defined therein.

The *DT80* can store more than one job (each with its own separate logged data and alarms), but only one can be the current/active job. See *Jobs* (P56) for more details.

Scaling and Calculations

The *DT80* can scale the channel input data to engineering units by applying intrinsic functions, spans or polynomials. Arithmetic expressions provide cross-channel and other calculations. Various statistical functions, including averaging and histogram channel options, can be applied. See *Scaling* (P60).

Reducing Data

In many instances the volume of the data recorded can be reduced by taking averages, maximums, minimums, standard deviations, histograms or integrals. See *Statistical Channel Options* (P70).

Alarms and Conditional Execution

The *DT80*'s alarm facility is flexible and powerful. Alarms are used to warn of certain conditions (e.g. setpoint exceeded) and to control the *DT80*'s operation. Alarms can

- control *DT80* digital state outputs
- initiate execution of *DT80* commands
- trigger the sending of messages to the host computer.
- set variables

Executing *DT80* commands from an alarm can be particularly useful in modifying the *DT80*'s programming in response to changes in input(s). See *Alarms* (P76).

Data Logging

The *DT80* stores measurements in its internal data store or in a removable USB memory device.

Logging begins only after you issue the **LOGON** command. Time and date stamping is automatic.

By default, the *DT80* overwrites the oldest data with new data once the memory is full. If you prefer to have the logger stop logging once the memory is full then you need to set the no-overwrite schedule option (**NOV**) (P45).

For more details see *Logging and Retrieving Data* (P86)

Selective Logging

To selectively log channels and schedules:

- For channels, use the **NL** (no log) channel option
- For schedules, use the **LOGON***x* & **LOGOFF***x* commands

See *Enabling and Disabling Data Logging* (P86).

Retrieving Data

The *DT80* can do two things with the data it measures:

- Return it immediately to the host computer, where it can be seen arriving on-screen. This monitoring function is data return in **real time**.
- Store it in its internal memory and/or an inserted USB memory device ready for retrieval (unload) to the host computer at a later time. This is data **logging**.

The *DT80* can carry out these functions separately, or at the same time.

Retrieving Real-Time Data

The *DT80*'s default is to return data in ASCII text form to a connected host computer instantaneously – that is, as it is measured. (To override this send the **/r** switch to the data logger (P203)).

The logger's inbuilt *dEX* software can also display real-time data in tabular form in your web browser, or you can define

mimics to display the data in graphical form such as dials or trend charts.

Note that if the *DT80* is configured to take measurements at a rapid rate then it is possible that not all data values will be returned. All measurements will, however, be logged (if logging is enabled).

Retrieving Logged Data

Data stored in a *DT80*'s internal memory or USB memory device can be retrieved (or **unloaded**) by means of the Host RS-232 port, the Ethernet port, or the USB port. Data can be retrieved for an individual schedule or all schedules, or for all jobs or an individual job.

USB memory devices

The *DT80*'s USB port supports USB memory devices, which can be used

- as a medium for transferring logged data from the internal memory of a *DT80* to a computer (see *Retrieving Logged Data* (P90))
- as removable data storage. See *Logging Data* (P86)
- to load a job into a *DT80.* See *ONINSERT Job* (P59).
- to upgrade a *DT80*'s firmware. See *Firmware Upgrade – USB Flash Device* (P322).

Data stored on the USB memory device is in a Windows-compatible file structure – see *The DT80 File System* (P104).

Format of Returned Data

As mentioned earlier, the *DT80* can:

- make data available to a host computer as it is measured (**real-time** data), and/or
- store data in memory to be retrieved at a later date (**logged** data)

You can control whether data is returned or logged on a per channel, per schedule or global basis.

Real-time data

Web Access (dEX)

If the *DT80* is connected to a host computer via a TCP/IP network then the logger's built in web interface can be used to display real-time data in any web browser. This may be presented in tabular numeric format, or as graphical "mimic" displays. See *Displaying Real-Time Measurements* *(P131)*.

ASCII Data

The *DT80* can also return real-time data in ASCII (text) form via its command interface. This can be in one of two formats:

- free format mode
- fixed format mode (also known as "host mode", or "formatted mode")

The **/h** switch command selects free format mode (which is the default); **/H** selects fixed format mode.

Free Format Mode /h

In free format mode, data is returned as human-readable ASCII text. Various settings are available to control how the data is presented. By default, each channel is printed on a separate line, prefixed by its name (either a standard *DT80* channel name e.g. "3TK", or a user-specified name e.g. "Inlet temp") and followed by appropriate units.

Thus the following program:

```
RA30S 1V("Pressure~kPa") 2TK 5DS("Valve state")
```

would result in text similar to the following text being sent to the active communications port:

```
Pressure 102.3 kPa
2TK 98.0 degC
Valve state 1 State

Pressure 107.3 kPa
2TK 98.2 degC
Valve state 1 State
```

and so on.

By applying various formatting settings you can get different results. One possible example would be:

```
/n/c/u/T P33=10 RA30S 1V("Pressure~kPa",FF2) 2TK(FF2) 5DS("Valve state")
```

which would format the data thus:

```
12:46:00.029     102.32      97.98          1
12:46:30.017     107.34      98.22          1
```

In this example, **/n/c/u** are **switch commands** *(P203)* that have been used to switch off output of channel numbers, channel names and units. The **/T** switch causes each data record to be prefixed by a timestamp. **P33=10** is a **parameter setting** *(P200)* that sets each data value to a fixed width (10 characters). Finally, the **FF2 channel option** *(P43)* specifies that the channel value is to be rounded to 2 decimal places.

Fixed Format Mode /H

Fixed format mode is designed for use with *dataTaker* host software. Data is still returned in ASCII form, but the record format is **fixed** to allow it to be easily parsed by a computer. If **/H** is specified then both of the above examples will return data as:

```
D,081044,"JOB1",2005/03/29,12:46:00,0.0293681,0;A,0,102.322,97.979902,1;0072;065F
D,081044,"JOB1",2005/03/29,12:46:30,0.0170320,0;A,0,107.341,98.220014,1;0072;3BEB
```

In fixed format mode:

- all formatting commands (e.g. **FF2**, **/n**, channel names) are ignored – fixed settings are used
- all records are prefixed by a **header**, which specifies that this is a data record (D), from *DT80* serial number 081044, running a job called "JOB1". This is followed a timestamp (date, time, and sub-second time). The 0 indicates that this is real-time data, the A identifies the schedule, and the 0 is the index within the schedule of the first data value.
- floating point data values are always specified to 8 significant digits
- each record includes an error-detection code (CRC) on the end. This allows host software to reject corrupted records.

Data records such as the above are only one of several types of fixed format message. A comprehensive description of all fixed format message types is beyond the scope of this manual.

Logged Data

This section discusses the different formats in which logged data can be retrieved. For details on how to go about retrieving your data, what mechanisms are available (web, file, FTP etc.) and what commands and options to use, see *Retrieving Logged Data* (P90).

CSV Format Data

CSV (comma separated value) is a widely used text based format for transferring data. The *DT80* command **COPYD** can be used to report logged data in CSV format. Data can be written to either:

- the active comms port, so the data appears in the *dEX* or *DeTransfer* command window from which the **COPYD** command was issued, or
- a file on the *DT80*'s internal file system, or
- a file on a removable USB device, or
- a file on an FTP server

CSV Record Format

By default, the *DT80* merges logged data and alarms from multiple schedules into a single file. The file consists of a number of **rows**. Each row is terminated by a CR-LF sequence.

Each row consists of a number of **fields** (columns), separated by commas.

Each row consists of the following fields, in order:

- timestamp (e.g. `2010/03/01 09:54:38.000`)
- timezone. Currently, this field will always have the value "`n`", meaning "no timezone"
- data values for first schedule (zero or more fields, one for each loggable channel). Numeric data values are specified in "mixed" format (may be either standard or exponential format), to 8 significant digits and trailing zeroes after the decimal point are trimmed. String values are enclosed in quotes, with any control characters represented in `^c` form (e.g. a CR character would appear as `^M`).
- alarm number, alarm state (0-3) and alarm text (see *Alarm Records* (P84)) for first schedule (three fields; only present if schedule has one or more loggable alarm channels)
- data values for second schedule (if any)
- alarm number, alarm state and alarm text for second schedule (if any)
- (and so on, for each schedule)

The first row in the file is a **header row**, which contains a descriptive name for each field. For example, the name of a data value field has the form "*chanName (units)*", e.g. `"Ext Temp (degC)"`

The first block of rows after the header row contain all data records for the first schedule. The next block of rows contain all alarm records for the first schedule. Then comes the data records for the second schedule, and so on.

In other words, the CSV data is generated in schedule order, not in time order. However, once it is loaded into a spreadsheet it is a trivial exercise to re-sort by the timestamp field.

Example

For example, a typical file might look like:

```
"Timestamp","TZ","Ext Temp (degC)","2V (mV)","1CV","B.ALnum","B.ALstate","B.ALtext"
2010/03/01 09:54:38.000,n,22.896844,-0.05822
2010/03/01 09:54:39.000,n,22.894454,-0.058563
2010/03/01 09:54:40.000,n,22.899576,-0.057869
2010/03/01 09:54:41.000,n,22.897856,-0.056656
2010/03/01 09:54:42.000,n,22.893504,-0.05735
2010/03/01 09:54:38.233,n,,,3
2010/03/01 09:54:40.249,n,,,4
2010/03/01 09:54:42.237,n,,,1
2010/03/01 09:54:40.249,n,,,,2,1,"trig 22.9"
```

Variations

To simplify parsing by host applications, the CSV format files generated by the *DT80* are essentially fixed format. However the following parameters may be used to vary the format:

- **P38** can be used to change the character used as the decimal point. By default, this is set to 46, which is the ASCII code for a period character (`.`). For European applications, it is often set to 44, which is the code for comma (`,`). If this is set to comma then the data separator is automatically changed to semi-colon (`;`).
- **P41** can be used to change the number of decimal places shown for timestamp values (default 3).

For example, setting

```
P38=44 P41=0
```
would result in:

```
"Timestamp";"TZ";"Ext Temp (degC)";"2V (mV)";"1CV";"B.ALnum";"B.ALstate";"B.ALtext"
2010/03/01 09:54:38;n;22,896844;-0,05822
2010/03/01 09:54:39;n;22,894454;-0,058563
2010/03/01 09:54:40;n;22,899576;-0,057869
2010/03/01 09:54:41;n;22,897856;-0,056656
2010/03/01 09:54:42;n;22,893504;-0,05735
2010/03/01 09:54:38;n;;;3
2010/03/01 09:54:40;n;;;4
2010/03/01 09:54:42;n;;;1
2010/03/01 09:54:40;n;;;;2;1;"trig 22.9"
```

Data in this format can then be readily imported into spreadsheet applications which are set up for a European locale.

Error Values

In the event of an erroneous sample value, e.g. analog input overrange, or calculation error, a textual error string will be inserted into the CSV data in place of the data value, e.g.

```
2010/03/01 09:54:40.000,n,OverRange,-0.057869
```

When this is imported into a spreadsheet application, the non-numeric data value will typically plot as zero.

Native (DBD) Format Data

When the *DT80* logs data to its internal memory, it stores it in fixed size data files, one for each schedule. These files have a **.DBD** file extension, e.g. **DATA_A.DBD**.

An alternative way of getting data out of a *DT80* is to transfer relevant **.DBD** files to the host computer. These files can then be opened using tools such as:

- dataTaker *dump_dbd* (which can convert to CSV format). This utility is available on the dataTaker resource CD or on the **datataker.com** website.
- third party packages such as *DPlot,* which provides plotting facilities.

For large data files, it is often significantly faster to transfer data in DBD format, as the *DT80* does not need to perform any data conversion and formatting.

Native format *DT80* data files can be saved to files on the *DT80* internal file system, a USB memory device or an FTP server. As with CSV format output, this is done using the **COPYD** command; the only difference being that a **format=dbd** option is specified.

For more details, see *Retrieving Logged Data* *(P90)*.

Fixed Format Data

Logged data may also be unloaded to a file as fixed format records, as described in *Fixed Format Mode /H* *(P25)*. This is primarily intended for use with legacy host applications such as *DeLogger*.

To retrieve data in fixed format, use **COPYD format=fixed**.

Free Format Data

Data may also be unloaded in traditional dataTaker "free format" mode, as described in *Free Format Mode /h* *(P25)*. This format may be customised using a number of parameter and switch settings.

To retrieve data in fixed format, use **COPYD format=free**.

Part B – Channels

Channel Definitions

A **channel definition** defines a measurement to be taken. It is therefore the fundamental building block that you use when programming the *DT80*.

Channel definitions are normally enclosed in a **schedule definition**. The schedule definition specifies when to take the measurements. The channel definitions specify what to measure, on which terminals and how to sample and process the data value.

A sample schedule definition is shown below

```
RA2S   2DS   3R(4W)   2*V(0.1,GL3V,"Speed~km/h",FF0)   9CV(W)=9CV+1
```

This shows four channel definitions which are part of the "A" schedule. Each time this schedule runs (which will be every 2 seconds), four measurements will be taken:

1. The logic state of digital channel 2 will be sampled
2. A resistance connected to analog channel 3 (4-wire connection) will be measured
3. A voltage connected to analog channel 2 (* and # terminals) will be measured and displayed as a speed value
4. An internal general purpose variable will be updated (incremented)

Let us now examine the syntax of a channel definition more closely.

A channel definition consists of up to four components

- the **channel type** is a mnemonic code which tells the *DT80* what sort of quantity is being measured, or what sort of sensor is attached. In the above example the channel types are **DS** (digital state), **R** (resistance), **V** (voltage) and **CV** (channel variable). A channel definition must always include a channel type.
- a **channel number** prefix is required for most channel types. This specifies which channel to measure. In the above example we are measuring digital channel **2**, analog channel **3**, analog channel **2*** and internal variable #**9**
- **channel options** are enclosed in round brackets after the channel type and further specify how the channel is to be measured and processed. In the above example, the **3R**, **2*V** and **9CV** channels have user-specified options, the **2DS** channel does not.
- some channel types are "writable" (e.g. internal variables and digital output channels) and therefore allow a value to be assigned using an **expression**. In the above example the **9CV** channel definition contains an expression.

Channel Numbers

A *DT80* **channel number** identifies a particular channel within a certain **class** of channels. The following table lists the various classes of *DT80* channels. As can be seen, each class has its own range of channel numbers.

channel class	terminal labels	channel numbers	applicable channel types
analog	**1** – **16** *(DT85)* **1** – **5** *(DT80)* **1** *(DT81)* **1** – **20** *(CEM20)*	1 – 16 *(DT85)* 1 – 5 *(DT80)* 1 *(DT81)* 1 – 2 *(DT82E)* *n*01 – *n*20 *(n = CEM20 number)* plus optional * + – # modifier	V HV I L R BGI BGV AS F FW T*x* AD5*xx* CU NI LM*x*35 LM*xx* PT3*xx* TMP*xx* YS*xx*
digital	**1D – 8D** *(DT80/85)* **1D – 4D** *(DT81)*	1 – 8 *(DT80/85)* 1 – 4 *(DT81/82E)*	C DB DBO DN DNO DS DSO
counter	**1C – 4C**	1 – 4 1 – 7 *(DT85/85L-3)*	HSC
		1 – 2 *(DT80/85)* 1 *(DT81)* 1 – 3 *(DT85/85L-3)*	PE
relay	**RELAY**	1	RELAY
LED	**Attn**	1	WARN
serial		1 – 3 *(DT80/85)* 2 – 3 *(DT81)* 2 *(DT82E)*	SERIAL MODBUS
		1 *(DT80/85 only)*	SSPORT
TCP/IP		4	MODBUS
power output	**12V** **5V SW**	no number	PWR12V PWR5V
SDI-12	**5D – 8D** *(DT80/85)* **4D** *(DT81/82E)*	5 – 8 *(DT80/85)* 4 *(DT81/82E)*	SDI12
channel variable	internal	1 – 1000	CV
system variable	internal	1 – 53	SV
string	internal	1 – 50	$
timer	internal	1 – 4	ST
temperature reference	internal	no number *(DT8x)* 1 – 15 *(CEM20)*	REFT
special	internal	no number	D T DELAY CALC &*name* CMRR IBAT R100 VANA VBAT VC VDD VEXT VLITH VREF VRELAY VSYS VZERO

The "applicable channel types" column lists the different ways in which a physical input can be measured. For example, analog channel **1** can be used to measure a voltage (specified by entering 1V), or a PT385 RTD (1PT385) or a frequency (1F). All of these **channel types** fall into the analog class, so when we talk about channel 1 we are talking about **analog** channel 1.

Because each channel type is a member of one class only, there is never any confusion about which "channel 1" is being referred to. 1C refers to **digital** input 1 because, from the above table, the C (counter) channel type is in the digital class. 1HSC, on the other hand, refers to **counter** input 1 because the HSC (high speed counter) channel type is in the counter class.

An **analog** channel number can be suffixed by a **modifier** character, which identifies the pair of terminals between which to measure, as shown in the following table:

Modifier	Measure voltage between
none	**+** and **-**
*	* and **#**
+	**+** and **#**
–	**-** and **#**
#	**#** and **AGND/EXT#** (normally only used for current measurements)

Thus the channel ID 3V defines a measurement between the + and – terminals, while 3*V, 3+V and 3–V define measurements between the *, **+** or **–** terminals (respectively) and the **#** terminal.

Channel Number Sequence

A channel ID that contains two channel numbers separated by two decimal points (for example, **1..3**) defines a **continuous sequence** of channels. If the channel IDs include terminal modifiers then the sequence will include all terminal modifiers between that of the first channel ID and that of the second (inclusive, in the order *****, **+**, **–**, **#**, and only where valid for the channel type). For example

Sequence	is equivalent to
1..4V	**1V 2V 3V 4V**
1#..3#I	**1#I 2#I 3#I**
1+..3-R(3W)	**1+R(3W) 1-R(3W) 2+R(3W) 2-R(3W) 3+R(3W) 3-R(3W)**

Channel Types

The following table lists all of the channel types supported by the *DT80*. For each channel type, the table shows:

- the **channel type** mnemonic (e.g. **HV**). Remember that in most cases this will be prefixed by a channel number. Refer to *Channel Numbers* *(P29)* for details of the allowable range of channel numbers for each channel type.
- whether the channel type is "**writable**" (shown in the Channel Type column). Writable channel types can be assigned a value, e.g. **2C=200** or **1CV=(2CV+3)+SIN(5CV)**
- the **default channel options** for this channel type. These override the standard default values shown in the channel option table. See also *Channel Options* *(P37)*.
- what the **channel factor** does for this channel type
- the **units** in which data will be returned. By default, the indicated units string will be shown on the display and appended to free format returned data, although it can be overridden if required.
- references to further details about the channel type

Category	Channel Type	Signal\ Sensor Details	Default Channel Options	Channel Factor	Output Units	More Information
Voltage	**V**	Voltage input ranges are ±3V, ±300mV & ±30mV	**(U)** *Note 1*	scaling factor	mV	*Voltage* *(P234)*
	HV	Higher Voltage input ranges are ±30V, ±3V & ±300mV	**(A)**	scaling factor	V	
Current	**I**	Current	**(100,T)** *Note 1, 2*	current shunt Ω	mA	*Current* *(P237)*
	L	4-20mA current loop	**(100)** *Note 2*	current shunt Ω	%	
Resistance	**R**	Resistance by 2, 3 or 4-wire methods, 10kΩ maximum.	**(I,3W)**	offset adjust Ω *Note 4*	Ohm	*Resistance* *(P239)*
Bridge	**BGI**	4-wire bridge, 3-wire simulated bridge current excitation	**(350,II, 3W)**	arm resistance Ω	ppm	*Bridges* *(P242)*
	BGV	4 & 6-wire bridges, voltage excitation .	**(V,4W)**	offset adjust ppm *Note 4*	ppm	*Bridges* *(P242)*
Frequency	**F**	Frequency measurement	**(30,T)** *Note 1*	sample period ms	Hz	*Frequency* *(P253)*
	FW	Vibrating Wire Strain Gauge frequency *DT80G/85G only*	**(200,MD350)**	sample period ms	Hz	*Strain Gauges – Vibrating Wire* *(P255)*
Temperature	**TB**, **TC**, **TD**, **TE**, **TG**, **TJ**, **TK**, **TN**, **TR**, **TS**, **TT**	Thermocouples Type B, C, D, E, G, J, K, N, R, S and T	**(T)** *Note 1*	scaling factor	degC *Note 3*	*Temperature – Thermocouples* *(P246)*
	PT385 **PT392**	Platinum RTDs (α = 0.00385, 0.00392)	**(100,3W, II)**	0°C resist-ance Ω	degC *Note 3*	*Temperature – RTDs* *(P249)*
	NI	Nickel RTD (α = 0.005001)	**(1000,3W, I)**	0°C resist-ance Ω	degC *Note 3*	

Category	Channel Type	Signal\ Sensor Details	Default Channel Options	Channel Factor	Output Units	More Information
	CU	Copper RTD (α = 0.0039)	**(100,3W, II)**	0°C resist-ance Ω	degC *Note 3*	
	YS01 **YS02** **YS03** **YS04** **YS05** **YS06** **YS07** **YS16** **YS17**	Thermistors: Yellow Springs 400XX series	**(3W,I)**	parallel resistor Ω	degC *Note 3*	*Temperature – Thermistors (P248)*
	AD590 **AD592** **TMP17**	Semiconductor current source types (Analog Devices)	**(100,V,U)** *Note 2*	current shunt Ω	degC *Note 3*	*Temperature – AD590 Series IC Sensors (P250)*
	LM135 **LM235** **LM335**	Semiconductor (zener diode) voltage output types	**(2,V)**	scaling factor	degC *Note 3*	*Temperature – LM135 Series IC Sensors (P252)*
	LM34 **LM35** **LM45** **LM50** **LM60** **TMP35** **TMP36** **TMP37**	Semiconductor voltage output types	**(V)**	offset adjust °C *Note 4*	degC *Note 3*	*Temperature – LM35 Series IC Sensors (P251)*
Time, Date and System Timers	**T** *writable*	Time of day				*Time (P33)*
	D *writable*	Day or date				
	1ST **2ST** **3ST** **4ST** *writable*	System timers Increment every sec (**1ST**), min (**2ST**), hour (**3ST**), day (**4ST**)	**(60)** **(60)** **(24)** **(7)**	range	Counts	*System Timers (P34)*
Delay	**DELAY** *writable*	Delays schedule execution for nominated time			ms	*Delay (P35)* *Note 6*
System Data	**SV** *some are writable*	System variable		scaling factor		*System Variables (P35)*
Variables	**CV** *writable*	Channel variables: general purpose holders for data, calculation results		scaling factor		*Channel Variables (nCV) (P63)*
	IV	Integer variables		scaling factor		*Rainflow Cycle Counting (P73)*
Calculation	**CALC** *writable*	Temporary holder for calculation result		scaling factor		*Calculation Only Channels (P64)*
Reference	**&***name*	Last measurement value for channel called *name*		scaling factor		*Reference Channels (P64)*
Text	**$** *writable*	General purpose text for headings, etc. (max. 80 characters each)				*Text (P34)*
Serial	**SERIAL**	Transmit to and receive from serial device	**(***P53***)** ie. P53 specifies default timeout	timeout (sec)	State	*Generic Serial Channel (P277)*
	SDI12	Control SDI-12 sensors using digital channels 5-8	**(AD0,R1)**	scaling factor		*SDI-12 Channel (P272)*
	SSPORT *writable*	Enable/disable serial sensor port *(not DT81)*		delay (ms) *Note 6*	State	*Serial Interface Power Control (P286)*
Modbus	**MODBUS**	Read/control Modbus sensors	**(MBI,MES, TO3,RT0)**	scaling factor		*Modbus Channel (P290)*

Category	Channel Type	Signal\ Sensor Details	Default Channel Options	Channel Factor	Output Units	More Information
Power Output	**PWR12V** *writable*	Enable/disable 12V power output *(Series 2)*		delay (ms) *Note 6*	State	*Controlling 12V Power Output (P225)*
	PWR5V *writable*	Enable/disable isolated 5V power output *(Series 3)*		delay (ms) *Note 6, 7*	State	*Controlling 5V Power Output (P225)*
Digital Input	**DS**	Digital state input (1 bit)			State	*Digital Inputs (P262)*
	DN	Digital nybble input (4 bits)	**(15)**	bit mask *Note 5*	Nybble	
	DB	Digital byte input (8 bits)	**(255)**	bit mask *Note 5*	Byte	
	AS	Digital state input on an analog channel	**(2500)**	threshold (mV)	State	*Analog Logic State Inputs (P260)*
Digital Output	**DSO** *writable*	Output on a single digital channel.		delay (ms) *Note 6*	State	*Digital Outputs (P263)*
	DNO *writable*	Nybble output on a group of digital channels	**(15)**	bit mask *Note 5*	Nybble	
	DBO *writable*	Byte output on a group of digital channels	**(255)**	bit mask *Note 5*	Byte	
	RELAY *writable*	1=Relay output closed 0=Relay output open		delay (ms) *Note 6*	State	
	WARN *writable*	1=**Attn** LED on 0=**Attn** LED off		delay (ms) *Note 6*	State	
Counter	**C** *writable*	Pulse count on digital input (0 to range-1)		range	Counts	*Counters – Low Speed (P267)*
	HSC *writable*	High Speed Up Counter (0 to range-1)		range	Counts	*Counters – High Speed (P268)*
	PE *writable*	Phase Encoder			Counts	*Phase Encoders (P270)*
Internal Maintenance	**REFT**	Reference temperature of *DT80* or CEM20 terminal block		scaling factor	degC *Note 3*	*Temperature – Thermocouples (P246), CEM20 Temperature Reference (P305)*
	VBAT	Terminal voltage of internal 6V lead acid battery		scaling factor	V	Battery flat if below 5.6V.
	VLITH	Internal Lithium memory-backup battery voltage.		scaling factor	V	Replace battery if below 2.8V.
	IBAT	Internal main battery current		scaling factor	mA	Positive if charging, negative if discharging
	VREF	Analog 2.5V voltage source reference		scaling factor	V	
	VZERO	Analog zero voltage reference		scaling factor	mV	
	R100	Internal 100 Ohm Shunt		scaling factor	Ohms	
	VANA	Internal analog 3.8V rail voltage		scaling factor	mV	
	VDD	Internal 3.3V rail voltage		scaling factor	mV	
	VSYS	Internal system supply rail voltage		scaling factor	mV	
	VRELAY	Internal relay supply voltage		scaling factor	mV	
	VEXT	Raw voltage onto system from external supply		scaling factor	V	
	CMRR	Common-mode rejection ratio at maximum gain			dB	

Table 2: DT80 Channel Types

Notes

1. Input termination is on by default **(T)** for DT80/81 Series 1 for non-attenuated measurements between + and - terminals
2. If the current shunt value is specified (as the channel factor) then that value is used. Otherwise, if the measurement uses the *DT80*'s internal shunt on the # terminal (e.g. **3#I**), then the *DT80* uses the actual calibrated resistance of its

shunt. Otherwise, the external shunt is assumed to be 100.0 ohms.

3. Alternatively, parameter P36 can be set to force all temperatures to be returned in `degF`, `degR` or `K`.
4. Offset corrections are subtracted from the measured value.
5. The bitmask specifies which channels are affected by a multi-bit read or write. Channels where the corresponding bitmask bit is zero are not affected. For example **`1DNO(3)=0`** will set digital outputs **1D** and **2D** low but the state of outputs **3D** and **4D** will be unchanged.
6. The *delay* channel factor can be used in conjunction with the **`R`** channel option to generate a fixed width pulse output.

   Note: use *delay* carefully as it prevents execution of any other schedules, measurements or outputs during the delay.
7. 5V power output will only be active while analog section is powered; use **`P21=1`** if continuously power output is required.

Internal Channel Types

The *DT80* has its own internal channels, which can be read in exactly the same way as the obvious "external" channels. Use the channel types below.

Time

The *DT80*'s real-time clock/calendar has a resolution of 0.1ms, based on a 24-hour clock. Time is read in the same way as any channel, but without a channel number. That is, sending

```
T
```

returns

```
Time 11:45:10.213
```

This channel type is writable, so you can set the time by sending:

```
T=12:20:00
```

Time can be in several formats, selected by parameter P39 as follows:

P39=	Format	Example
0 (default)	Hours:minute:seconds.subseconds P41 controls the number of sub-second digits between 0 and 6; default is 3 digits	`11:45:10.003`
1	s.s (decimal seconds) since midnight	`42310.003`
2	m.m (decimal minutes) since midnight	`705.1667`
3	h.h (decimal hours) since midnight	`11.7528`

If the time is assigned to a channel variable (see *Channel Variables (nCV)* *(P63)*) then the CV will contain the number of seconds since midnight, e.g.

```
T(=1CV) 1CV
Time 17:40:50.748
1CV 63650.7
```

You can also set the time using a CV, e.g.

```
1CV=7200 T=1CV
1CV 7200.0
Time 02:00:00.000
```

See also *Setting the System Time* *(P207)*.

Date

The current date can also be returned and set:

```
D
Date 22/05/2005
D=25/12/2010
Date 25/12/2010
```

Date can be in several formats, selected by P31 as follows:

P31=	Format		Example
0	Day number	DDDDD	`86`
1 (default)	European	DD/MM/YYYY	`28/03/2002`
2	North America	MM/DD/YYYY	`03/28/2002`
3	ISO	YYYY/MM/DD	`2002/03/28`

If the date is assigned to a channel variable then the CV will contain the number of seconds since 1-Jan-1989. The date can also be set from a CV, e.g.

```
D(=1CV) 1CV=1CV+86400 D=1CV
Date 04/03/2010
1CV 668176400.0
Date 05/03/2010
```

System Variables

The following system variables (see *System Variables* (P35)) return date related information which can then be tested in alarms:

- **12SV** returns the current date/time as decimal days since 1-Jan-1989
- **15SV** returns the day number of the year (0-365)
- **20SV** returns the day of the month (1-31)
- **21SV** returns the month (1-12)
- **22SV** returns the year (1989-9999)

Text

Fifty 80-character text channels (**1$** – **50$**) are available for labelling, data headings, site identification, *DT80* identification, and so on.

Define the string by sending, for example

```
2$="my text string^M^J"
```

Then, the string is returned (unloaded) whenever *n*$ is included in a channel list.

Text channels can also be set based on data returned via the serial channel. *Control String – Input Actions* (P282)

Control characters may be included in the text string, e.g. **^M** for carriage return.

Internal Maintenance

There are several internal maintenance channels, which are read in the same way as normal channels. These allow, for example, the terminal voltage of the *DT80*'s internal batteries to be measured. See the *Internal Maintenance* section of the *DT80* Channel Types table (P30).

System Timers

There are four internal reloading system timers, which are read in the same way as channels. The four timers increment at the following rates, and reset to zero when their range (maximum value) is reached:

System Timer	Channel Type	Increments Every	Default range	Provides
1	**1ST**	1 second	60 (1 minute)	Second of the minute
2	**2ST**	1 minute	60 (1 hour)	Minute of the hour
3	**3ST**	1 hour	24 (1 day)	Hour of the day
4	**4ST**	1 day	7 (1 week)	Day of the week: (0 = Sunday, 1= Monday, etc.)

System timers are normally synchronised to the previous midnight or Sunday, and increment at the beginning of each second, minute, hour or day.

If the *DT80*'s date/time is set, the system timer channels will be updated to match the new time.

The range of a system timer can be set using the channel factor. For example, **2ST(15)** will count from 0 to 14, resetting every quarter hour, on the quarter hour.

If the range is set to 0 then the timer will not reset, except at midnight (1-3ST) or midnight Sunday (4ST)

If a system timer is explicitly set to a value, e.g. **1ST=12**, then it will no longer necessarily be synchronised to the actual time. In this example, after being set 1ST will count up from 12 to 60, at which point it will reset back to 0 and start counting again. It will always differ from the time-of-day seconds count by a fixed offset.

If a system timer's range is set, it will automatically be resynchronised to the actual time. Therefore **2ST(60)** can be entered at any time to return 2ST to its default behaviour.

If a system timer is set to a value outside its range, it is immediately adjusted so that it is in range. When you enter *n***ST=***x*, you are actually doing *n***ST=***x* mod *range*. Thus **2ST=62** will actually set 2ST to 2.

Examples

Assume the time is now 12:34:56. Then:

```
2ST
2ST 34      (34 minutes past the hour – counter resets on the hour)
2ST(0)
2ST 754     (754 minutes since midnight – counter resets at midnight only)
2ST(22)
2ST 6       (754 mod 22 – counter resets at midnight and every 22 minutes thereafter)
2ST=1
2ST 1       (counter is no longer synchronised to midnight)
2ST(22)
2ST 6       (setting range value resynchronises timer to current time)
```

2ST will now increment every minute, resetting back to 0 each time it reaches 22. When midnight comes around, it will again be reset to 0.

Delay

It is often useful to insert a fixed delay into a *DT80* program. There are two ways of doing this, each for a particular purpose.

As discussed in *Executing Commands in Schedules* *(P54)*, there is a distinction between **channel definitions** and **commands**. Channel definitions (**1V**, **T**, **5SDI12** etc) are executed as part of a schedule. Any commands (**U**, **G**, **DELDATA** etc.) triggered by the schedule (using **ALARM** or **DO** statements) will be queued but not executed until the schedule completes.

The **DELAY=***n* channel definition will insert a delay of *n* ms between two channel definitions. For example:

```
RA20S 1WARN=1 DELAY=1000 1WARN=0
```

will turn on the **Attn** LED, wait one second, then turn it off. (There are more better and more compact ways to do this, e.g. **1WARN(1000,R)=1**; the above is simply to illustrate a point.)

On the other hand, the **PAUSE** *n* command will insert a delay of *n* ms between two commands. The following will do a similar thing to the previous example:

```
RA20S DO{SATTN; PAUSE 1000; CATTN}
```

In this case the **SATTN** and **CATTN** commands are used to turn the **Attn** LED on and off, rather than the **1WARN** channel.

Delay Accuracy

The actual delay will not necessarily be exactly as specified. For delays of 20ms or less it will be close (within 1ms). For longer delays the resolution is +/- 16ms however it is guaranteed that the duration will be at least the specified time.

For the **DELAY** channel type, the **PT** (precise timing) channel option may be specified to force a precise delay time, even if the duration is greater than 20ms. For example:

```
DELAY(PT)=1000
```

Note however that during this time all logger operations including communications, display updates and sampling will be suspended.

Note Performing long delays using the **DELAY** channel or the **PAUSE** command is not recommended as it can prevent the timely evaluation of other schedules. This is true regardless of whether the **PT** option is specified.

System Variables

System variables provide various pieces of information about the state of the *DT80* and its current job. All system variables are read-only except where indicated as **writable** in the table below.

As with any other channel type, SVs are, by default, displayed to one decimal place. Use the **FF***n* channel option to vary this if required, e.g. **14SV(FF2)**

System Variable	Function	Notes	Writable
1SV	Free space in the internal file system (B:)	in kBytes	
2SV	Used space in the internal file system (B:)	in kBytes	
3SV	Free space in USB memory device (A:)	in kBytes, 0 if no memory device present	
4SV	Used space in USB memory device (A:)	in kBytes, 0 if no memory device present	
5SV	External power status	0 = external power not connected 1 = external power connected	
6SV	Build number of the *DT80*'s firmware	e.g. = 2 for firmware version 6.18.0002	
7SV	Job loaded flag	0 = no current job 1 = a job is loaded	
8SV	Mains frequency setting in Hz (P11)	Can be used to change P11 within a schedule	☑
9SV	USB memory device presence	0 = none 1 = USB memory device inserted	
10SV	ID of the owning schedule	0 = RX schedule 1 = RA schedule ↓ 11 = RK schedule 12 = immediate schedule	
11SV	Returns 0.0	Can be used as thermocouple reference channel for cases where the thermocouple output is already compensated, e.g. **RA1S 11SV(TR) 1TT**	
12SV	Decimal days since base date (00:00, 1-Jan-1989)		
13SV	*DT80* serial number		
14SV	Version number of the *DT80*'s firmware	e.g. = 6.18 for firmware version 6.18.0002	
15SV	Day number of the current year (integer)	0 = 1st of January	
16SV	Host RS-232 port input handshake line states	Bitmask, 0 to 15 8 = RI, 4 = DCD, 2 = DSR, 1 = CTS	

System Variable	Function	Notes	Writable
17SV	Host RS-232 port output handshake line states	Bitmask, 0 to 3 2 = DTR, 1 = RTS	☑
18SV	Serial Channel input handshake line states (RS232 mode only)	Bitmask, 0 to 1 1 = CTS	
19SV	Serial Channel output handshake line states (RS232 mode only)	Bitmask, 0 to 1 1 = RTS	☑
20SV	Current day of the month	1 - 31	
21SV	Current month	1 - 12	
22SV	Current year	1989 - 5999	
25SV	Status of a modem connected to the *DT80*'s Host RS-232 port	0 = no modem connected (direct connection assumed) 1 = modem connected and no call in progress 2 = modem connected and call in progress	
26SV	Status of last NTP attempt	0 = no NTP requests have been attempted 1 = time adjustment in process 2 = last request successful -1..-5 = last request unsuccessful	
27SV	Time discrepancy as at last NTP request	in milliseconds	
29SV	Status of last unload attempt	0 = no unloads have been attempted 1 = unload in progress 2 = last unload was successful -1..-9 = FTP connection error -10..-19 = transfer error -20..-29 = source store file error -99 = unload aborted by user	☑
30SV	Number of logged data records for RX schedule	-1 = no current job; or no storefile has been created for the specified schedule in the current job	
31SV	Number of logged alarm records for RX schedule		
32SV	Number of logged data records for RA schedule		
33SV	Number of logged alarm records for RA schedule		
	↓		
52SV	Number of logged data records for RK schedule		
53SV	Number of logged alarm records for RK schedule		

Table 3: DT80 System Variables

Channel Options

Overview

All channel types can be modified in various ways by **channel options**, which define the way in which the input channel is managed when sampled. There are channel options that specify the type of sensor excitation, the termination of the input channel, scaling and linearization of the input signal, the format and destination of channel data, fixed channel gain values, resistance and bridge wiring methods, statistical operations on the channel data, and so on.

As shown below, channel options are placed in round brackets immediately following the channel ID (channel number and type). If multiple channel options are specified then they should be separated by a comma (no spaces).

```
RA2S 1TK 3R(4W) 2*V(0.1,GL3V,"Speed~km/h",FF0)
```

In the above example:

- The first channel, **1TK**, has no channel options specified so it will measure the thermocouple using default settings.
- The second channel (**3R**) includes the **4W** channel option, which specifies that a 4-wire resistance measurement should be taken.
- Finally, the **2*V** channel is in this case used to read a speed sensor which outputs a voltage that is directly proportional to speed (10mV per km/h). The **0.1** channel option is the **channel factor**, which for a voltage channel is interpreted as a simple scaling factor (mV * 0.1 = km/h). The **GL3V** (gain lock) option tells the *DT80* to select the 3V measurement range (rather than auto-ranging). The last two options concern the presentation of the data on the LCD display and in returned real-time data when in free format (**/h**) mode. In particular, they define the channel name and units, and specify that no decimal places be displayed (**FF0**).

  The channel's data will therefore be returned/displayed as:

  ```
  Speed 72 km/h
  ```

  instead of the default:

  ```
  2*V 721.3 mV
  ```

Only certain channel options can be applied to each channel type. If an inappropriate channel option is applied (or an incompatible combination of options), the *DT80* notifies by returning an `E3 - Channel option error` message.

The same channel can be put in the list more than once, with the same or different channel options. The *DT80* treats each occurrence as a separate measurement.

A Special Channel Option — Channel Factor

The *DT80*'s **channel factor** channel option is simply a floating point number. This number is interpreted in different ways depending on the channel type, as indicated by the following table.

Channel Type	Channel Factor's function
V, **HV**, **T***x*, **LM***x***35**, **CV**, **SV**, **CALC**, **&***name*, **MODBUS**, **SDI12**, internal channels e.g. **VBAT**, **REFT**	Scaling factor – for example, **1V(5.5)** means multiply the reading by **5.5**
I, **L**, **AD5***xx*, **TMP17** (current)	Resistance (ohms) of the external current shunt (the *DT80* uses this value and the voltage it measures across the shunt to calculate current flow)
BGI (current excited bridge)	Bridge arm resistance (ohms)
BGV (voltage excited bridge)	Offset adjustment (ppm)
PT3xx, **NI**, **CU** (RTD)	Resistance of the RTD element at 0°C (ohms)
YS*xx* (thermistor)	Value of connected parallel resistance (ohms)
R (resistance)	Offset adjustment (ohms)
AS (state)	Logic threshold value (mV)
F, **FW** (frequency)	Sample Period (ms)
C, **HSC**, **ST***x* (counter, timer)	Count modulo value (reset after every n counts)
DN, **DB**, **DNO**, **DBO** (digital multiple)	Bitmask (only channels with 1 in bitmask are read/output)
DSO, **WARN**, **RELAY**, **PWR12V**, **PWR5V** (digital output)	Delay time (ms)
SERIAL	Timeout (sec)

For example, the three channel definitions in the schedule command

```
RA30S 1V(10.1) 4PT385(200.0) 2DSO(100,R)=0
```

contain channel factor channel options that instruct the *DT80* to do the following:

- scale (multiply) the voltage measured on input channel 1 by **10.1**
- use **200.0**Ω (instead of the default 100.0Ω at 0°C) when calculating the temperature represented by the signal from the RTD on channel 4
- output a **100**ms pulse on digital channel 2.

Multiple Reports

The *DT80* samples each channel in the channel list once every scan. However, by adding additional **channel option sets** (each set enclosed in round brackets) you can generate additional reports. That is, you can report the same data value in different ways.

The first channel option set determines how the channel is sampled, and must include all sampling options required for the channel. These channel options are listed above the **configuration line** in the *Channel Option Table* *(P40)*. Second and subsequent option sets may only contain reporting options (those below the configuration line.

Multiple reports are particularly useful for statistical reports (see *Statistical Report Schedules* *(P52)*) in that several different statistical operations can be performed on the same data set.

For Example:

```
RA1H 3YS04(II,AV)(MX)(TMX)(MN)(TMN)
```

defines five option sets. The first option set specifies one sampling option (**II** – use 2.5mA excitation) and returns the average temperature value, calculated over the period (1 hour in this case) since the last report scan. The remaining option sets will return the maximum reading over the same interval, the time at which it occurred, the minimum and the time of minimum.

Remember that the first option set can contain options from any part of the channel option table, while subsequent option sets can only contain options from below the configuration line.

Mutually Exclusive Options

Options grouped by a shaded rectangle in the Mutual Exclusions column of the table below are **mutually exclusive**. If more than one channel option from a mutual exclusion group is placed in a channel list, only the **last** one specified is recognised.

Order of Application

The *DT80* applies channel options in a specific order, regardless of the order in which they are specified in a channel definition. The channel option table below lists the channel options more or less in the order of application.

In general terms, the ordering is as follows:

1. First, the raw value is sampled, taking note of **sampling options**, i.e. those relating to the physical measurement process. These include options in the input termination (**T**, **U**) , input attenuator (**A**, **NA**), resistance/bridge wiring (**2W**, **W**, **4W**), gain lock (**GL30V**, **GL3V**, **GL300MV**, **GL30MV**) and excitation (**I**, **II**, **V**, **E**, **N**) categories, along with **NSHUNT**, **2V**, **ES***n* and **MD***n*.

   The raw value may then be linearised according to the channel type, e.g. for thermocouples the appropriate polynomial will be applied to convert millivolts into a temperature value (in the units specified by P36).

   The resulting linearised value is then further processed as follows.
2. The **channel factor** is then applied, if specified. For most channel types this is a simple scaling (multiplier) value.
3. A **user specified scaling** option – a span (**S***n*), polynomial (**Y***n*), thermistor scaling (**T***n*) or intrinsic function (**F***n*) – is then applied.
4. The resulting scaled and linearised value may then be manipulated using a **data manipulation** option – difference (**DF**), time difference (**DT**), rate of change (**RC**), reading per time (**RS**) or integrate (**IB**).
5. A **digital manipulation** option for measuring the timing of signal transitions may then be applied (**TRR**, **TRF**, **TFR**, **TFF**, **TOR** or **TOF**)
6. The data value processed up to this point may then be used as a **reference** value for other measurements (**TR**, **BR** or **TZ**)
7. The data value may then be accumulated using one or more **statistical** options (each one in a separate option set). Statistical channel options include **AV**, **SD**, **MX**, **MN**, **TMX**, **TMN**, **DMX**, **DMN**, **IMX**, **IMN**, **INT**, **NUM** and **H** (histogram).
8. Finally, the resultant value after applying the above options (or values if multiple option sets are used) may be stored in a channel variable using **=CV** and *op*=**CV** options. Return, logging and/or display of the data may be disabled using the **NR**, **NL**, **ND** and **W** options, and output formatting can be specified using **FF***n*, **FE***n* and **FM***n* and **"***name~units***"**.

Default Channel Options

All channel options have default values. The *DT80* follows a 3-step procedure to determine what options to apply:

1. Start with the basic set of default options specified in the channel option table.
2. If the **channel type** specifies any default options then they are applied, overriding any conflicting basic default options. Default options for each channel type are listed in the channel type table refer *Table 2: DT80 Channel Types* *(P32)*
3. Finally, if an option is explicitly specified in the channel definition then that setting is used, overriding any default setting. If more than one **mutually exclusive** option is specified then only the **last** one is used, e.g. **`1V(AV,MX)`** is interpreted as **`1V(MX)`**. (If you want to output both the average and the maximum then use two separate option sets, i.e. **`1V(AV)(MX)`**.)

For example, if you specify:

`1R(4W)`

then you are really specifying:

`1R(U,NA,N,ES0,MD10,FF1,I,3W,4W)`

In this case the basic default options are **`(U,NA,N,ES0,MD10,FF1)`**. The **`R`** channel type specifies **`(I,3W)`** as its default options, so the **`(I)`** option (200µA excitation) overrides the **`(N)`** option (no excitation). Then the user specifies **`(4W)`** which overrides the **`R`** channel type's default wiring option setting **`(3W)`**.

Channel Option Table

Category	Channel Option	Mutual Excl	Function	Range of Option (n)	Comment
Input Termination *(DT80/81 Series 1 only)*	**T**		Terminate +, – inputs with 1MΩ to **AGND** terminal		Provides input bias current path to ground to prevent inputs "floating" – particularly when independent (differential) inputs are used. Not required on DT80 Series 2 or DT85 as a ground path is always present.
	U *default*		Unterminate +, – inputs		
Input Attenuators	**A**		Enable ÷10 input attenuators		Attenuators default ON for **HV**, **AS** channel types, OFF for other types.
	NA *default*		Disable input attenuators		
Resistance and Bridge	**2W**		2-wire measurement		Specifies the number of wires run between the *DT80* and the resistance or bridge. More wires generally mean better accuracy.
	3W *default*		3-wire measurement		
	4W		4-wire measurement		
Gain lock	(none) *default*		Auto-range over 3 gain ranges		Selects between 3V, 300mV, 30mV ranges if input attenuators disabled Selects between 30V, 3V, 300mV ranges if input attenuators enabled
	GL30V		Lock channel gain for ±30V input signal range		Valid only if input attenuators are enabled
	GL3V		Lock channel gain for ±3V input signal range		
	GL300MV		Lock channel gain for ±300mV input signal range		
	GL30MV		Lock channel gain for ±30mV input signal range		Valid only if input attenuators are disabled
Excitation	**I**		Supply 200µA current excitation on * terminal		Precision current source. Low excitation current minimises self-heating in resistive temperature sensors and allows high resistances to be measured.
	II		Supply 2.5mA current excitation on * terminal		Precision current source. Higher excitation current allows more accurate measurement of low resistances (< 700Ω).
	V		Supply approx. 4.5V voltage excitation on * terminal		Voltage source is not regulated
	E		Connect external excitation source (**EXT** * terminal**)** to channel's * terminal		
	N *default*		No excitation by *DT80* (assumes externally applied excitation)		Excite terminal (*) may be used as a shared-terminal input channel
Channel Factor	*value*		Linearise/scale the measured value	depends on chan type	A scale factor or other parameter specific to channel type (see the channel factor column in *Table 2: DT80 Channel Types* *(P32)*)
Reference Offset	**2V**		Measure relative to 2.5V rather than 0V		Used with **F** channel type to set threshold to +2.5V (suitable for TTL level input signals) rather than the default of 0V.
Extra Samples	**ES***n* *default = 0*		Perform *n* additional samples and average them	0 to 30000	Can reduce noise. Total measurement time is *n*+1 mains periods. Analog channel types only.
Measurement Delay	**MD***n* *default = 10*		After selecting channel, delay for *n* ms before starting measurement	0 to 30000	Specifies the settling time required before a sensor can be measured. Default is 350ms for **FW** channel. Analog channel types only.
Low Threshold	**LT**		Set low input voltage thresholds for high speed counters		Valid for **1HSC**, **2HSC** (DT80/81/85) and **1PE** (not DT81) channels.

Category	Channel Option	Mutual Excl	Function	Range of Option (n)	Comment
Reset	**R**		Reset channel after reading		Valid for **C**, **HSC**, **ST** and **CV** channel types, which are reset to 0 after returning their current value. Also valid for digital output channel types (**DSO**, **DNO**, **DBO**) which invert the state of each bit after returning its value.
Internal Shunt *(DT80/81 Series 1 only)*	**NSHUNT**		Disconnect internal 100R shunt between # terminal and **AGND**		Allows # terminal to be used for shared-input voltage measurements
Delay	**PT**		Force precise timing		Valid for **DELAY**, **DSO**, **WARN** and **RELAY** channel types. Forces a precise (+/- 1ms) delay time even for long delays.
Scaling	**S***n*		Apply span *n*	1 to 50 (poly & span index is shared)	Applies a previously-defined span See *Spans (Sn)* *(P60)*
	SR*n*		Apply reversed span *n*		Applies a span in reverse See *Spans (Sn)* *(P60)*
	Y*n*		Apply polynomial *n*		Applies a previously-defined polynomial See *Polynomials* *(P61)*
	F*n*		Apply intrinsic function *n*.	1 to 7	*n* **Function** 1 1/x 2 √x 3 Ln(x) 4 Log(x) 5 Absolute(x) 6 X^2 7 Gray code to binary conversion (16 bit)
	T*n*		Apply thermistor scaling (correction) *n*	1 to 20	Applies a previously-defined thermistor scaling equation See *Thermistor Scaling* *(P61)* and *Temperature – Thermistors* *(P248)*.).
Data Manipulation	**DF**		Difference Δx		Returns the difference (xUnits) between the latest reading and the previous reading
	DT		Time difference Δt		Time difference (seconds) between the latest reading and the previous reading
	RC		Rate of change Δx / Δt		Rate of change (xUnits per second) based on latest and previous readings and their respective times
	RS		Reading / time difference x / Δt		Rate of change (xUnits per second). Useful when the sensor reading is already a difference (e.g. resetting counters)
	IB		"Integrate" (x – Δx / 2) Δt		"Integration" with respect to time (xUnits . seconds) between the latest and the previous readings (area under curve)
Digital Manipulation	**TRR**		Time from rising edge to rising edge		Normally used for digital channels. If used on analog channels then channel factor is interpreted as a threshold value.
	TRF		Time from rising edge to falling edge		
	TFR		Time from falling edge to rising edge		
	TFF		Time from falling edge to falling edge		
	TOR		Time of rising edge		
	TOF		Time of falling edge		
Reference Channel	**TR**		Use this channel's value as thermocouple reference junction temperature		Any non-thermocouple temperature sensor measuring isothermal block temperature. If already compensated use **11SV(TR)** as reference channel (11SV always returns 0.0). TR channel temperature is used for all subsequent thermocouple measurements in this schedule

Category	Channel Option	Mutual Excl	Function	Range of Option (n)	Comment
	TZ		Use this channel's value to correct the *DT80*'s electrical zero		This zero would be measured at the isothermal block TZ channel zero is used for all subsequent thermocouple measurements in this schedule
	BR		Use this channel's value as bridge excitation voltage		BR channel voltage used for all subsequent **BGV** measurements in this schedule
SDI-12	**AD***n*		Sensor address	0 to 9	See *SDI-12 Channel* *(P272)*
	R*nnn*		Register to read	1 to 999	
	CM		Configure sensor to measure continuously		
Modbus	**AD***n*		Sensor address (serial)	1 to 247	See *Modbus Channel* *(P290)*
	AD"*ip-addr***"**		Sensor address (TCPIP)	IP address	
	R*t*:*rrrr*:*b*		Register(s) to read or write	0:0 to 4:65536	
	MB*type*		data type: int16, unsigned16, int32, float32, Enron int32, Enron float32	**I**, **U**, **L**, **F**, **LE**, **FE**	
	ME*order*		32-bit word order: standard, reversed	**S**, **R**	
	TO*n*		comms timeout (sec)	1 to 255	
	RT*n*		max retries	0 to 25	
	MUID*n*		unit id	0 to 255	
Serial Channel	**"***commands***"**		Input and output actions	ASCII text	See *Generic Serial Channel* *(P277)*
Rainflow Cycle Analysis	**RAINFLOW**				See *Rainflow Cycle Counting* *(P73)*
CONFIGURATION LINE (see *Multiple Reports* *(P38)*)					
Statistical See *Statistical Channel Options* *(P70)*	**AV**		Average of channel readings		These channel options link the channel to the statistical sub-schedule RS. The channel is sampled at times determined by the RS trigger (which defaults to 1S). At the report time as determined by the report schedules, the statistical summary is reported. If insufficient samples have been taken before the reporting time, an error is reported (`NotYetSet`). .
	SD		Standard deviation of channel readings		
	MX		Maximum channel reading		
	MN		Minimum channel reading		
	TMX		Time of maximum channel reading		
	TMN		Time of minimum channel reading		
	DMX		Date of maximum channel reading		
	DMN		Date of minimum channel reading		
	IMX		Instant (time and date) of maximum		
	IMN		Instant (time and date) of minimum		
	INT		Integral for channel (using time in seconds)		
	NUM		Number of samples in statistical calculation		
	H*x*:*y*:*m*..*n***CV**		Histogram	*x*, *y* ±1e18 *m*, *n* 1-1000	Divide data range *x* to *y* into discrete buckets and accumulate in CVs the number of samples in each bucket See *Histogram (Hx:y:m..nCV)* *(P72)*
Variables See *Channel Variables (nCV)* *(P63)*	**=***n***CV**		Assign channel reading to channel variable. *n***CV** = reading	1 to 1000	Channel variables are like memory registers in a calculator. They can be assigned directly (e.g. **1CV=2.5**), or assigned a channel reading at scan time (e.g. **1V(=7CV)**).
	+=*n***CV**		Add channel reading to channel variable.	1 to 1000	

Category	Channel Option	Mutual Excl	Function	Range of Option (n)	Comment
			*n*CV = *n*CV + reading		The contents of a variable can also be read, modified and then updated. For example **1V(/=7CV)** means that the value of 7CV is divided by the reading on channel 1 and the result is returned to 7CV. Note that these actions occur only at report time and not during statistical sampling.
	−=*n***CV**		Subtract channel reading from channel variable. *n*CV = *n*CV – reading	1 to 1000	
	=n***CV**		Multiply channel variable by channel reading. *n*CV = *n*CV * reading	1 to 1000	
	/=*n***CV**		Divide channel variable by channel reading. *n*CV = *n*CV ÷ reading	1 to 1000	
	=*m***..***n***CV** (**MODBUS** channel only)		Assign values to a range of CVs		
Destination	**NR**		No return		Channels tagged with **NR** are not returned to the host computer (they may still be logged or displayed).
	NL		No log		Channels tagged with **NL** are not logged (they may still be returned or displayed).
	ND		No display		Channels tagged with **ND** are not displayed on the LCD (they may still be returned or logged).
	W		Working channel		Same as **(NR,NL,ND)** Working channels are usually used to hold intermediate values in calculations.
	LM		Log alarm measurement		Log the value being tested in an alarm. Ignored for non-alarm channels.
Output Data Format	**FF***n* *default = 1*		Fixed-point format *n*=decimal places	0 to 7	Specifies numeric format for display and free format (**/h**) real-time data. For example, **FF2** returns `71.46 mV` For example, **FE2** returns `7.14e1 mV` **FM***n* uses exponential format if exponent is less than –4 or greater than *n*
	FE*n*		Exponential format, *n*=decimal places	0 to 7	
	FM*n*		Mixed: FF or FE, *n*=significant digits	0 to 7	
	BG*min***:***max*				Show value as a bargraph on the display.
Channel name and Units	**"***name***"**		User-specified name Default units	ASCII text	Allows channel name and/or units to be overridden for display and free format (**/h**) real-time data. Max 24 characters for user-specified channel name; 10 characters for units.
	"*name***~***unit***"**		User-specified name User-specified units		
	"*name***~"**		User-specified name No units		
	"~*unit***"**		No channel name User-specified units		
	"~"		No channel name No units		

Table 4: DT80 Channel Options

Part C – Schedules

Schedule Concepts

What are Schedules?

Schedules are the workhorses of the *DT80*. They are the underlying structures that you use to manage the repetitive processes of the *DT80* such as

- scanning input channels
- evaluating calculations
- processing alarms
- managing output channels
- returning data to a host computer
- logging data.

The *DT80* supports the following schedules:

- 11 **general purpose** schedules, A-K, which can be triggered by a variety of different events
- a **polled** schedule, X, which is normally triggered by a poll command from the host computer (although most of the other triggers can also be applied to it, making it effectively a 12th general purpose schedule)
- the **immediate** schedule, which executes once immediately after being entered
- the **statistical** schedule, which collects and accumulates data to be returned as statistical summaries by the other schedules.

Schedule Syntax

A typical schedule definition is shown below:

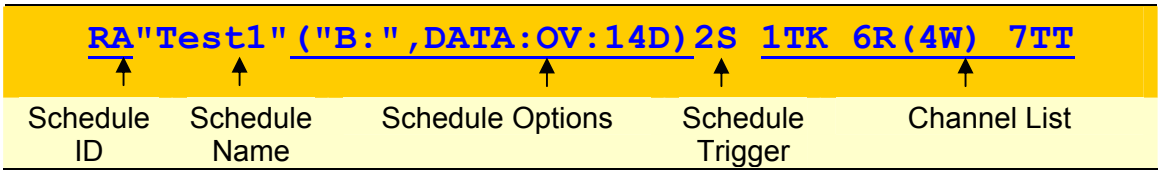
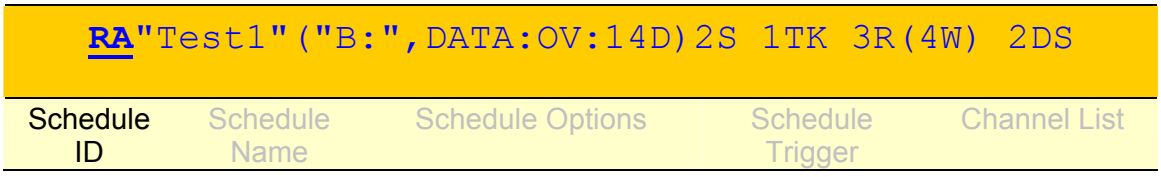


Figure 7: Components of a typical schedule command

A schedule consists of a number of parts. Firstly the Schedule ID, next the schedule options and finally the schedule trigger. There are no spaces between the different parts

Schedule ID



The **Schedule ID** consists of the letter **R** ("Report schedule") followed by a letter identifying the schedule.

Each schedule has a unique identifier; these are summarized in the following table:

	Schedule ID	Quantity
Report schedules *(P47)*	**RA, RB, RC, RD, RE, RF, RG, RH, RI, RJ, RK**	11 available
Polled schedule *(P51)*	**RX**	1 available
Immediate report schedule *(P51)*	No schedule ID	Each time you enter an immediate schedule it replaces the previous one, if any.
Statistical sub-schedule *(P52)*	**RS**	1 available, but is applied to one or more of the other report schedules

Schedule Name

```
RA"Test1"("B:",DATA:OV:14D)2S 1TK 3R(4W) 2DS
```

Schedule ID | **Schedule Name** | Schedule Options | Schedule Trigger | Channel List

The schedule name is optional, and consists of text (max 20 characters) enclosed in double quotes. This name is used in reports and is normally used to document the purpose of a given schedule.

Schedule Options

```
RA"Test1"("B:",DATA:OV:14D)2S 1TK 3R(4W) 2DS
```

Schedule ID | Schedule Name | **Schedule Options** | Schedule Trigger | Channel List

Schedule options are enclosed in brackets. They define:

- where to log the data and alarms generated by the schedule (i.e. internal file system or removable USB device)
- the amount of space to allocate for storing **data** records, and whether old records are to be overwritten when it is full.
- the amount of space to allocate for storing **alarm** records, and whether old records are to be overwritten when it is full.

For more details on how data logging works, see *Logging Data* *(P86)*

The schedule option syntax is as follows:

(*Dest***,DATA:***DataOverwrite***:***DataSize***,ALARMS:***AlarmOverwrite***:***AlarmSize***:***AlarmWidth***)**

Item	Possible Values	Explanation
Dest	**"A:"**	Logged data and alarm information from this schedule will be written directly to the USB memory device (not normally recommended, see *Logging Options* *(P88)*)
	"B:"	Logged data and alarm information from this schedule will be stored on the internal flash disk **(default)**
DataOverwrite	**OV**	Data for this schedule will be overwritten when the data store is full **(default)**
	NOV	Data will not be overwritten when the data store is full. When the data store fills logging will stop and the **Attn** LED will flash
DataSize	*n***B**	Allocate *n* bytes for storing data for this schedule
	*n***KB**	Allocate *n* kilobytes for storing data for this schedule
	*n***MB**	Allocate *n* megabytes for storing data for this schedule
	*n***R**	Allocate space for *n* data records for this schedule
	*n***S** *Note 1*	Allocate space for *n* seconds worth of data for this schedule
	*n***M** *Note 1*	Allocate space for *n* minutes worth of data for this schedule
	*n***H** *Note 1*	Allocate space for *n* hours worth of data for this schedule
	*n***D** *Note 1*	Allocate space for *n* days worth of data for this schedule
AlarmOverwrite	**OV**	Alarms for this schedule will be overwritten when the store is full **(default)**
	NOV	Alarms will NOT be overwritten when the store is full. When the store fills logging will stop and the 'Attn' LED will flash
AlarmSize	*n***B**	Allocate *n* bytes for storing alarms for this schedule
	*n***KB**	Allocate *n* kilobytes for storing alarms for this schedule
	*n***MB**	Allocate *n* megabytes for storing alarms for this schedule
	*n***R**	Allocate space for *n* alarm records for this schedule
AlarmWidth	**W***n*	Allocate *n* bytes for storing each alarm string **(default=60 bytes)**

Note 1: These are only valid for time-triggered schedules (not for polled or event triggered schedules). Furthermore, if the schedule rate is changed after the job has started running then the store file may no longer contain data for the indicated time span.

Default Schedule Options

All schedule options are optional. Default settings are:

- Destination is **B:** (internal flash drive)
- New data and alarms **overwrite** earlier data/alarms once the store file fills
- Space allocated for data is **1MB**

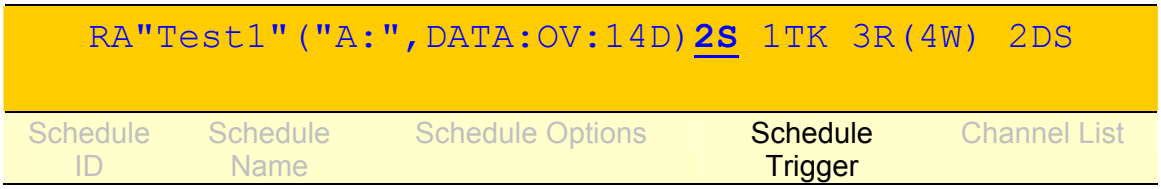
- Space allocated for alarms is **100KB**
- Space allocated for each logged alarm text string is 60 bytes.

Examples

```
RA"Fred"(DATA:NOV:15D)15M
```

Schedule A is given the name "Fred". Data and alarms are stored on the internal drive and sufficient space is allocated for 1440 readings (15 days worth, based on a 15 minute scan rate). In this case earlier data is considered more valuable than later data, so no-overwrite mode is selected. If any alarms are defined in this schedule they will use the default storage parameters (100KB, overwrite enabled)

Schedule Trigger

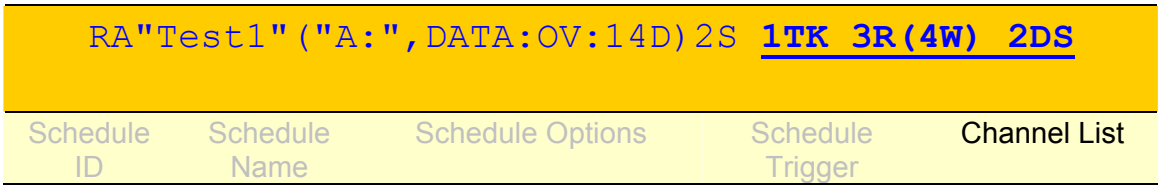


All schedules have a **trigger**, which defines when the schedule is to execute the processes assigned to it. Here are the *DT80*'s schedule triggers:

- an interval of **time**, see *Trigger on Time Interval* (P47)
- an **external event** (such as a digital input transition), see *Trigger on External Event* (P48)
- an **internal event** (such as a CV changing), see *Trigger on Internal Event* (P49)
- a **poll command**, see *Trigger on Schedule-Specific Poll Command* (P49)

Triggers can also be conditional upon an external or internal state (that is, trigger only while a particular external state or internal state exists) — see *Trigger While* (P50).

Channel List



Most often schedules will be created that instruct the *DT80* to carry out channel-related tasks, such as scanning one or more of its input channels and/or setting one or more of its output channels. When these schedules are created, group the channel details (their IDs and optional instructions) together in a **channel list** within the schedule. *Figure 7* (P44) shows a typical schedule — notice its schedule header and channel list components.

A channel list may contain just one channel entry or many, and each channel in the list must be separated from the next by one or more space characters. Similarly, a schedule's header must be separated from its channel list by one or more space characters.

The *DT80* processes the channels in a channel list from left to right.

Example — Channel List

The channel list

```
1V 3R 5..7DS 4TK("Boiler Temp") 3DSO=0
```

specifies the following channels (each is separated from the next by a space character):

- `1V` — read analog input channel 1 as a voltage
- `3R` — read analog input channel 3 as a resistance
- `5..7DS` — read the state of digital input channels 5 through 7 (inclusive)
- `4TK("Boiler Temp")` — read analog input channel 4 as a type K thermocouple and assign it the name **Boiler Temp**
- `3DSO=0` — set digital state output channel 3 low

Note that the example above is only a channel list and not a complete schedule. Here's the same channel list used in a schedule (the schedule header `RJ2M` has been added):

```
RJ2M 1V 3R 5..7DS 4TK("Boiler Temp") 3DSO=0
```

The header identifies the schedule as `R`eport schedule `J` that runs every `2` `M`inutes.

A Simple Schedule

A schedule comprises a schedule ID (schedule identifier), a trigger that determines when the schedule runs, and a list of processes to be carried out every time the schedule runs. For example, the schedule

```
RA10M 1V 3R
```

specifies report schedule A as follows:

- **RA** — schedule ID
- If logging is enabled then data will be stored to the internal flash disk, 1MB will be allocated and old data will be overwritten when full. This schedule does not define any alarms, so no alarm storage will be allocated.
- **10M** — trigger (run the schedule every 10 minutes)
- **1V 3R** — channel list

Groups of Schedules — Jobs

A *DT80* **job** is essentially a group of one or more schedules (each specifying a set of processes) that performs the overall task.

It's entirely at the user's discretion how the processes of an overall task are allocated between schedules; there are no hard-and-fast rules. For example, choose to differentiate schedules on the basis of function or purpose — some collect primary data, others perform intermediate calculations, others process alarms, and yet others are responsible for returning and logging data; or choose to assign a schedule to a single channel, such as the *DT80*'s Serial Channel.

See also *Jobs* (P23).

Types of Schedules

General-Purpose Report Schedules (RA, RB,…RK)

The *DT80* supports eleven general-purpose **report schedules**, which you use to carry out the repetitive processes of scanning input channels, evaluating calculations, handling alarms, managing output channels, returning and logging data, and so on.

These report schedules have the identifiers **RA**, **RB**, **RC**, **RD**, **RE**, **RF**, **RG**, **RH**, **RI**, **RJ** and **RK**.

A report schedule executes the processes assigned to it whenever it is triggered. A schedule trigger can be

- an interval of time
- an external event
- an internal event
- a poll request from a host computer.

Trigger on Time Interval

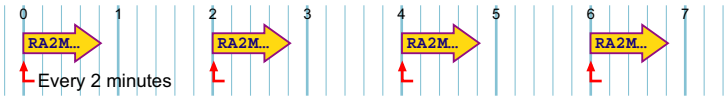


Figure 8: Time interval schedule

Report schedules can be triggered at regular intervals of time, determined by the *DT80*'s real-time clock. Intervals can be an integer number of seconds, minutes, hours or days:

Trigger	Run every n	Range
*n*D	Days	1 – 65535
*n*H	Hours	1 – 65535
*n*M	Minutes	1 – 65535
*n*S	Seconds	1 – 65535
*n*T	Milliseconds (Thousandths of seconds)	5 – 65535
none	Continuous	

Note The schedule first runs on the next multiple of the interval since last midnight (see *Time Triggers — Synchronizing to Midnight* (P54)), and subsequently runs every multiple of the interval thereafter. If the interval is not an even multiple of 24 hours, the *DT80* inserts a short interval between the last run of the schedule prior to midnight, and the run of the schedule beginning at midnight.

Examples — Trigger by Time Interval

The following schedule will execute every 5 seconds:

```
RA5S
```

The following schedule will execute continuously (as fast as possible):

```
RG
```

Trigger on External Event

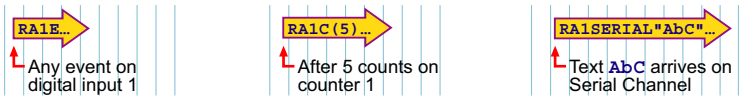


Figure 9: Various external event schedules

Report schedules can also be triggered by external events, which are manifested to the logger as state changes on the digital input channels *n*DS, or as pulses on the counter channels *n*C:

Trigger	Action
*n*E	Trigger on a rising or falling transition of digital input channel *n*
n+E	Trigger on a rising transition of digital input channel *n*
n−E	Trigger on a falling transition of digital input channel *n*
m..*n*E	Trigger on a rising or falling transition of any of digital input channels *m*..*n*
m..*n*+E	Trigger on a rising transition of any of digital input channels *m*..*n*
m..*n*−E	Trigger on a falling transition of any of digital input channels *m*..*n*
*n*C(*c*)	Trigger when low speed counter channel *n* "wraps around" (i.e. is reset to 0), which will occur when a count value of *c* is reached.
*n*HSC(*c*)	Trigger when high speed counter channel *n* "wraps around" (i.e. is reset to 0), which will occur when a count value of *c* is reached.
*n*SERIAL"*text*"	Trigger on the arrival of characters (from an external serial device) at the *DT80*'s Serial Channel (serial sensor port if *n* = 1, host port if *n* = 2). The trigger can be of the form 1SERIAL"", where any character arriving triggers the schedule (note that there is no space between ""), or 1SERIAL"AbC", where arrival of the exact string AbC triggers the schedule. See *Triggering Schedules* (P285).

where:

- *n* is a digital channel number
- *m*..*n* is a sequence of digital channel numbers (see *Digital Channels* (P261))
- *text* is a string of characters arriving at the *DT80*'s Serial Channel terminals from an external serial device

Note: For edge triggering the minimum pulse width is approximately 16ms.

Triggering on Preset Counters

If a counter is preset to a value greater than its specified trigger count, the schedule is not triggered. For example, a schedule set to trigger after 10 counts on digital counter 2 (2C(10)) cannot be triggered if counter 2 is assigned a value of 15.

Examples — Trigger on Digital Channel Event

The schedule header

```
RC1E
```

instructs the *DT80* to run report schedule C on every transition of digital input **1D**.

The following schedule will run whenever digital input **3D** receives a low to high (positive/rising) transition:

```
RA3+E
```

Examples — Trigger on Counter Event

The following schedule will run on every 100th pulse received on high speed counter input **1C**:

```
RA1HSC(100)
```

In this case counter 1HSC will count from 0 to 99 then reset to 0, at which time the schedule will trigger. This means that if you read the value of 1HSC within this schedule then it will generally always read 0.

The following schedule will on every second pulse received on digital input **1D**:

```
RA1C(2)
```

Examples — Trigger on Serial Channel Event

The following schedule will run if the specific character sequence Pasta8zZ is received on the serial sensor port:

```
RB1SERIAL"Pasta8zZ"
```

The following schedule will run each time any string is received on the host port (assuming the port has been configured for serial channel operation):

```
RG2SERIAL""
```

Trigger on Internal Event

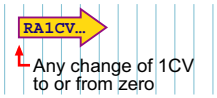


Figure 10: Internal event (CV change) schedule

Report schedules can also be triggered by internal events, this must be specified to the *DT80* as channel variables (CVs) changing value:

Trigger	Action
*n*CV	Trigger on any change of *n*CV to zero or from zero
n+CV	Trigger on any change of *n*CV from zero
n–CV	Trigger on any change of *n*CV to zero

where *n* is the channel variable number. (See *Channel Variables (nCV)* (P63).

Examples — Trigger on Internal Event

The schedule header

```
RK6CV
```

instructs the *DT80* to run **R**eport schedule **K** upon any change of channel variable 6 to or from zero. For instance, the schedule RK

- will trigger when 6CV changes from 0.0 to 1.0, from 0.06 to 0.0, or from –1.3 to 0.0
- will not trigger when 6CV changes from 0.0 to 0.0, 7.0 to 6.0, or from –112.3 to 0.001.

The schedule header

```
RK12+CV
```

instructs the *DT80* to run **R**eport schedule **K** whenever the value of channel variable 12 changes from 0 to any value.

Trigger on Schedule-Specific Poll Command

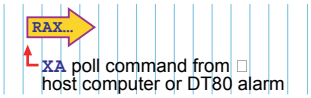


Figure 11: Polled schedule

Instead of a time or event trigger, the poll trigger (**X**) can be applied to a report schedule. Then the schedule can be polled (that is, information requested) at any time by the appropriate schedule-specific poll command **X***a* (where *a* is the schedule letter).

The poll command can be issued

- by a host computer, or
- by an alarm action (see *Using an Alarm to Poll a Schedule* (P83)).

See also *Digital Outputs* (P263)

Example — Trigger on Schedule-Specific Poll Command

The schedule

```
RDX 1..3TK
```

samples analog channels 1 to 3 as type K thermocouples (**1..3TK**) whenever the *DT80* receives an **XD** poll command (that is, whenever it receives the character sequence **XD**) either from a connected computer, or by means of an alarm action from within the *DT80*.

Using Poll Commands with Standard Report Schedules

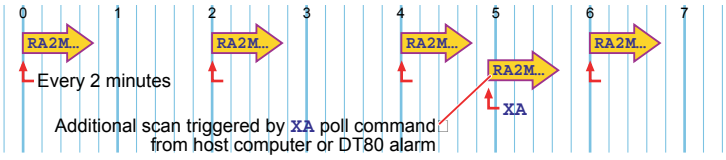


Figure 12: Polling a time interval schedule

A report schedule defined with a time or event trigger can also be polled by its appropriate poll command at any time. For example, the report schedule

```
RC5M 1V 2V 3V
```

normally runs every 5 minutes (**5M**), but it can also be run at any time by an **XC** poll command (from the host computer or an alarm).

For schedules that have a long interval, this is useful for checking that a sensor is functioning.

Trigger While

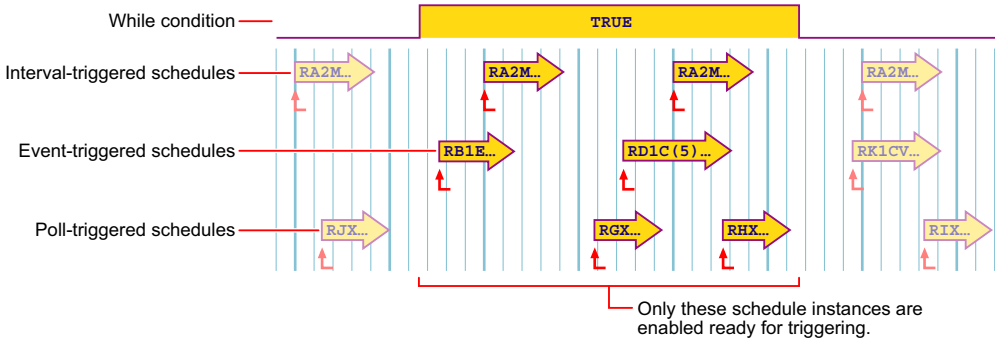


Figure 13: Schedule "while" condition

A report schedule's trigger can be enabled or disabled by an external condition. This is called the **While** condition — that is, trigger only while the external or internal condition is true.

The While condition can be either

- states on one or more of the *DT80*'s digital input channels (*n*`DS`), or
- internal conditions specified to the *DT80* as states of channel variables:

While clause	Action
`:`*n*`W`	Enable schedule While digital input *n* is high (true)
`:`*n*`~W`	Enable schedule While digital input *n* is low (false)
`:`*m*`..`*n*`W`	Enable schedule While ANY digital input *m* to *n* is high (true)
`:`*m*`..`*n*`~W`	Enable schedule While ANY digital input *m* to *n* is low (false)
`:`*n*`CV`	Enable schedule While *n*`CV` is non-zero
`:`*n*`~CV`	Enable schedule While *n*`CV` is zero

Note that the colon (`:`) is required.

Examples — While Condition

The schedule header
`RA1E:2W`
instructs the *DT80* to run `R`eport schedule `A` on every transition of digital input 1 (`1E`) only while digital input 2 is high (`:2W`).

The schedule header
`RD1S:4~W`
instructs the *DT80* to run `R`eport schedule `D` every second (`1S`) while digital input 4 is low (`:4~W`).

The schedule header
`RK2H:9W`
instructs the *DT80* to run `R`eport schedule `K` every two hours (`2H`) while digital input 9 is high (`:9W`).

The schedule header
`RC5M:12CV`
instructs the *DT80* to run `R`eport schedule `C` every 5 minutes (`5M`) while channel variable 12 is not zero (`:12CV`).

The schedule header
`RF6..8E:5W`
instructs the *DT80* to run `R`eport schedule `F` on any transition of digital channels D6, D7 or D8 (`6..8E`) while digital input 5 is high (`:5W`).

Continuous Report Schedules (No Trigger)

Figure 14: Continuous schedule

Report schedules that run continuously can be created. These schedules start scanning as soon as they are received by the *DT80* (they are not activated by a trigger), and run until it is stopped (by sending a halt command or resetting the *DT80*, for example).

Define a continuous schedule simply by omitting the trigger from a report schedule.

Example — Continuous Schedule

Sending
`RA 1TK 2R(3W) 3TT`
causes the *DT80* to scan channels 1, 6 and 7 continuously.

Special-Purpose Report Schedules

Polled Report Schedule (RX)

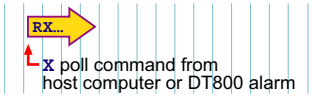


Figure 15: Polled X schedule

The **polled schedule** is a report schedule with a trigger of "request information now" command issued

- by a host computer connected to the *DT80* during data acquisition, or
- by an alarm action (see *Using an Alarm to Poll a Schedule* (P83)).

The *DT80* supports one polled schedule. It is specified by the **RX** schedule ID, and triggered by an **X** poll command (that is, by an **X** character followed by CR) sent from the host computer or from an alarm.

Channels, calculations and alarms included in a polled schedule are processed, reported and/or logged once every time the *DT80* receives an **X** poll command.

Note that underneath, the X schedule is really the same as the general purpose schedules. It can therefore be used as a 12th general purpose schedule, except that:

- the continuous trigger is not available. The syntax **RX** is treated the same as **RXX**, i.e. it specifies a polled trigger, not a continuous trigger,
- a single **X** character can be used to poll the schedule, which is treated the same as **XX**.

Example — Polled Report Schedule

The schedule

```
RX 1V 2V
```

runs once every time the *DT80* receives an **X** (or **XX**) command.

Immediate Report Schedules

Figure 16: Immediate schedule

Instead of scanning according to time or event triggers, **immediate schedules** run immediately — and once only — when they are received by the *DT80*.

An immediate schedule is simply a list of input channels, output channels, calculations and/or alarms with no schedule header (that is, no schedule ID and no trigger). The *DT80* executes the list (up to the next carriage return) immediately and once only.

Note Any data resulting from an immediate schedule is returned to the host computer, but is not logged.

Example — Immediate Report Schedule

Sending

```
1TK 2R(3W) 3TT
```

causes the *DT80* to immediately scan channels 1, 6 and 7 once only and return the data. Notice that this schedule has no schedule ID and no trigger.

Cautions for Using Immediate Schedules

When programming the *DT80*, give an immediate schedule time to execute before issuing a following **BEGIN** command, otherwise the immediate schedule's data may not be returned. Using *DeTransfer* can be helpful, by inserting a **\W** wait command (for example, **\W5**, which pauses program execution for five seconds — between immediate schedule commands and a **BEGIN** command.

If successive immediate schedules are entered too rapidly, then the channels may be appended as if they were part of a single schedule. Setting P22=13 (see *P22* (P201)) can overcome this by ensuring a return character is placed after each reading.

Re-Running an Immediate Schedule

The last-entered immediate schedule can be run again by sending the * (asterisk) command — that is, by sending a * character.

Statistical Report Schedules

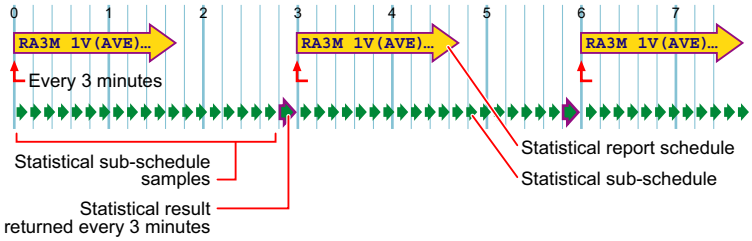


Figure 17: Statistical and report schedules

A report schedule can instruct the *DT80* to return statistical information (average, SD, max., min.,…) for one or more channels. The *DT80* does this by

- scanning its input channels and executing calculations at frequent intervals of time, then
- retaining intermediate values to produce a statistical data summary at longer intervals.

Note that there are two schedules involved:

- The primary statistical data is collected at frequent intervals, which are determined by the **statistical sub-schedule RS**.
- The statistical data summary (average, SD,…) is returned and logged at longer intervals, which are determined by the report schedule that is requesting the statistical information — the **statistical report schedule**.

Think of the statistical sub-schedule as a fast schedule (the slave) running within/below its slower statistical report schedule (the master). This is why **RS** is called the statistical sub-schedule.

The statistical sub-schedule has its own interval trigger. The default is one second, but you can change that — see *Redefining the Statistical Sub-Schedule's Trigger* (P52) below.

To return statistical data, include — in any report schedule — a statistical channel option for the specific input channels, calculations, and so on where statistically scanned is required. For example

```
RA1H 2TT(AV)
```

returns, every hour (**RA1H**), the average of one-second readings (because one second is the default scan rate for the statistical sub-schedule) taken from the type T thermocouple connected to channel 2 (**2TT(AV)**).

Note:

- Simply including a statistical channel option (**(AV)** in the example above) invokes the statistical sub-schedule.
- There is no need to include RS, the statistical sub-schedule's ID, anywhere (unless you want to alter RS's trigger — see *Redefining the Statistical Sub-Schedule's Trigger* (P52) below).

For details of the statistical channel options available, see *Statistical Channel Options* (P70).

Redefining the Statistical Sub-Schedule's Trigger

The statistical sub-schedule's trigger can be altered from its default of one second. Define the statistical sub-schedule's trigger in the same way as for report schedules (see *Changing a Schedule Trigger* (P53)), by using the **RS** schedule ID and sending an **RS**... schedule command to the *DT80*. If you don't specify the **RS** schedule's trigger in this way, it defaults to once per second. Here are some examples:

The schedule header	instructs *DT80* to accumulate specified statistical data
RS10S	every 10 seconds
RS1-E	on each 1 to 0 transition of digital input 1
RS	continuously

Statistical Sub-Schedule Halt/Go

The statistical sub-schedule can be halted by sending the **HS** command, and start it again by sending the **GS** command.

Important Because statistical sampling of channels stops the moment the **HS** command is sent, be aware that the reported statistical summaries do not include data from this halt period. This is most significant for the integral summary.

See also *Halting & Resuming Schedules* (P54).

Multiple Statistical Information for a Channel

If more than one type of statistical information is required for a channel, then each statistical option must be placed in a separate channel option list. For example, the channel list

```
1TT(AV) (SD) (MX)
```

results in periodic average, standard deviation and maximum data for the **1TT** channel.

Insufficient Statistical Samples

If no statistical data has been scanned before being reported, then the reported data value will be set to `NotYetSet`. This will also occur if **insufficient** samples have been taken – for example, the standard deviation (**SD**) option requires at least two samples to be able to return a value.

This condition may occur when

- the statistical sub-schedule is event-triggered
- the statistical sub-schedule has been halted
- a statistical sub-schedule scan interval is longer than its statistical report scan interval.

Example — Statistical Report Schedule

The command

```
RS10S RA1H 1TT 2TT(AV)(MX)
```

sets the statistical sub-schedule's scan rate to 10 seconds (**RS10S**). The main report schedule returns three temperature readings: a spot reading of channel 1 each hour (**RA1H 1TT**), and the average and maximum over the hour from 10-second samplings of channel 2.

Working with Schedules

Entering Schedules into the *DT80* (BEGIN–END)

Report schedules must be entered into (that is, sent to) the *DT80* as a group. Since the schedules and processes that comprise a job or program often extend over more than one line, you normally enclose them between the keywords **BEGIN** and **END** to designate the beginning and end of the group. Here's an example:

```
BEGIN"walrus"
 1DSO=1
 3CV(W)=2
 RA10S
  4TT("Oven Temp")
  5TT("Flue Temp")
 RB1S
  2C("Water Flow")
END
```

A group of schedules such as this is called a **job**. In the above example, the job has been named "walrus" and comprises two report schedules, **RA** (which measures two thermocouples every 10 seconds) and **RB** (which measures a counter once a second). Note also the two "immediate" channels (**1DSO** and **3CV**) which are not part of any schedule. These are executed once only, when the job is entered.

For more details on how jobs are entered and processed, see *Jobs* *(P56)*

Triggering and Schedule Order

When different schedules are due to trigger at the same time, the schedules execute in the order of **RA**, **RB**,…**RK**.

When there are statistical channels in a schedule and the statistical sub-schedule is due at the same time as the report schedule, the statistical sub-schedule runs prior to the report schedules. You cannot change this order.

Channels within schedules are sampled in the order of entry (left to right).

Changing a Schedule Trigger

The schedule's trigger can be changed at any time simply by sending a new schedule ID and trigger without any channel definitions. For example, suppose a schedule had been defined as follows:

```
RA10M 1V 2DS
```

This will measure a voltage and a digital input every 10 minutes. If you then send:

```
RA10S
```

the schedule will then, from that point on, measure every 10 seconds.

Important If any channel definitions are included on the same line (e.g. **RA10S 2V**) then this will be interpreted as a whole new job being entered, which will replace the currently running job.

Halting & Resuming Schedules

Schedules can be halted individually or as a group using the following commands:

Command	Function
H	Halt all schedules
HA, **HB** … **HK**	Halt **RA**, **RB**,…**RK** schedule
HS	Halt the statistical sub-schedule (see *Statistical Sub-Schedule Halt/Go* (P52))

Schedules can then be resumed ("GOed") individually or as a group:

Command	Function
G	Resume all schedules
GA, **GB** … **GK**	Resume **RA**, **RB**,…**RK** schedule
GS	Resume the statistical sub-schedule (see *Statistical Sub-Schedule Halt/Go* (P52))

Executing Commands in Schedules

It is important to distinguish between **commands** and **channel definitions**. Commands (e.g. **H**, **/S**, **P11=60**, **DIRJOB**, **COPY** etc.) are always executed once only, immediately they are received – even if they appear to be within a schedule definition.

For example, if you enter

```
RA1+E 1V HB SATTN 4CV=4CV+1
```

you might expect that when the schedule was triggered (by a positive going edge on digital input 1) it would measure a voltage (**1V**), halt schedule B (**HB**), switch on the **Attn** LED (**SATTN**) and increment a channel variable (**4CV=4CV+1**).

In fact, the **HB** and **SATTN** will execute once only, when the job is entered. The **1V** and **4CV=4CV+1** are channel definitions, so they will execute each time schedule A is triggered.

To execute commands within a schedule, the **DO** construct can be used. This is actually a special case of the **ALARM** statement (see *Alarms* (P76)) – one where the condition is always true. The syntax is the same as **ALARM** except that there is no test condition.

So if the above job was rewritten as:

```
RA1+E 1V DO{HB SATTN} 4CV=4CV+1
```

then the following actions would be performed each time schedule A is triggered:

- Channel **1V** is measured, then channel variable **4CV** is incremented
- The commands **HB** and **SATTN** are queued for execution. They will be actioned "as soon as possible" – once all schedules that are currently due have completed, and any previously queued commands have been executed.

Note that this means that it is not possible to interleave the execution of commands and channels within a schedule. Channels are always performed first; commands are executed a short time later.

Commands can also be executed conditionally, using the **IF** construct (which in fact is just a synonym for **ALARMR** – repeating alarm), e.g.

```
RA1M IF(1CV>3.57){XB}
```

will test the value of 1CV once a minute. If it exceeds 3.57 then schedule B will be triggered.

For more details on **ALARM**/**IF**/**DO** syntax and usage, see *Alarms* (P76).

Time Triggers — Synchronizing to Midnight

Time triggers for report schedules function in two different ways depending on the setting of the synchronize-to-midnight switch (**/s** or **/S**, see (P203)).

Synchronize-To-Midnight Switch Enabled

If the synchronize-to-midnight switch is enabled (**/S**, the *DT80*'s default), the intervals of all schedules with time triggers are synchronized to the previous midnight.

When a time-triggered schedule is entered, the schedules first run on the next multiple of the interval since last midnight, and subsequently run on every multiple of the interval thereafter.
If the interval is not an even multiple of 24 hours, the *DT80* inserts a short interval between the last run of the schedule prior to midnight and the next run of the schedule at midnight.

For example, if you send the schedule

```
RA10H
```

to the *DT80* at 06:00:00, it first runs at 10:00:00 (4 hours since entry, but 10 hours since midnight) and then at 20:00:00 that day; then at 00:00:00, 10:00:00 and 20:00:00 the next day; and so on.

If you enter an interval longer than 24 hours then the interval is rounded down to the nearest multiple of 24 hours. So if the

schedule

RA50H

was entered at 09:00 Monday morning then the schedule will first run at 00:00 Wednesday morning, then every 48 hours thereafter.

Synchronize-To-Midnight Switch Disabled

If the synchronize-to-midnight switch is disabled (**/s**), the schedules run at intervals relative to the time that the schedule is entered. For example, if the same **RA10H** schedule is sent to the *DT80* at 09:30:00, it first runs at 19:30:00 that day; then at 05:30:00 and 15:30:00 on the next day; at 01:30:00 and 11:30:00 on the following day; and so on. That is, every 10 hours of elapsed time.

Note that the base time (the time at which the specified schedule interval begins) is reset whenever:

- the schedule rate is changed, or
- the schedule is restarted (using the **G** command), or
- the system time is changed (using the **D=**, **T=** or **DT** commands)

Part D – Jobs

What is a Job?

A **job** is a collection of related schedule definitions and commands which together configure the *DT80* to perform a particular data logging task.

Several different jobs can be stored on the *DT80*'s internal file system, but only one can be active at any one time. Each job has its own separate data/alarm storage area.

Jobs are identified by their **job name**, which is a user-defined string of up to 8 characters. If a job name is not specified when the job is entered, the default name **UNTITLED** is used.

When the *DT80* is first started or reset, there is no active job. The logger is idle and `No current job` is displayed on the LCD to indicate this.

To make the logger do something useful, you need to either:

- enter a new job, or
- run (load) an existing job.

Once a job has been entered or loaded successfully, it becomes the currently active job and its name will be displayed on the LCD. If you then enter or load a different job, all schedules and channels defined by the original job are cleared and replaced by those of the new job.

Entering a Job

To enter a new job you send the required commands and schedule definitions to the logger using one of the communications ports (USB, Ethernet or RS232). Once the complete job has been entered, the *DT80* will automatically store the job in its internal file system and activate it.

To begin entering a new job, the **BEGIN** command is used. This command:

- causes the currently active job to be cleared. All defined schedules will stop running.
- specifies the name of the new job, e.g. **BEGIN"GOOSE"** indicates that the new job will be called "GOOSE". (Just **BEGIN** by itself is equivalent to **BEGIN"UNTITLED"**.)
- places the *DT80* in "job entry mode". After each line of the job is entered the *DT80* will output a `job>` prompt, rather than the usual `DT80>` prompt.

As each line of the job is entered the *DT80* executes any commands or immediate channels that it finds. Report schedule definitions, including their constituent channel definitions are recorded but they are not activated just yet.

The **END** command marks the end of a job. At this point all schedules defined within the job are activated, and the *DT80* is no longer in job entry mode.

If an error occurs during job entry, the *DT80* will clear all schedule/channel definitions and ignore the remainder of the job, up until the **END** command is seen.

Note In some circumstances the *DT80* will not allow a new job to be entered:

- if the "fix schedules" switch *(P203)* is active (**/F**) – this prevents any change to the currently active job. (Use **/f** command to allow the current job to be changed.)
- if a different job with the same name already exists, and it has been locked using the **LOCKJOB"***jobname***"** command – this prevents a stored job being accidentally overwritten. (Choose a different job name, or unlock the existing job using **UNLOCKJOB"***jobname***"**.)
- if a different job with the same name already exists, and it has logged data or alarms – this prevents data from different jobs (which happen to have the same name) from being mixed up in the one data file. (Choose a different job name, or delete the existing job's using **DELDATA"***jobname***"** and/or **DELALARMS"***jobname***"**.)

Note An error message will be returned if you attempt to send more than 255 characters on a single line.

Single Line Jobs

As a shortcut, it is also possible to enter a job simply by entering one or more schedule definitions all on one line, e.g.:

```
RA1S 1TK
```

The above is then equivalent to:

```
BEGIN"UNTITLED" RA1S 1TK END
```

that is, it will create a new job called "UNTITLED".

Note that entering just a schedule trigger (with no channel definitions after it), e.g.

```
RA2S
```

does not create a new job – it simply changes the trigger condition for the currently defined A schedule (if any).

It is recommended that, for clarity, **BEGIN** and **END** are always included explicitly when entering a job.

Loading an Existing Job

The *DT80* can also read job text from a file stored in its internal file system and automatically enter it. This job will then become the current active job, replacing whatever was previously the current active job.

A new job may be loaded when:

- the **RUNJOB"***jobname***"** command is issued. This will read the job from the file **B:\JOBS***jobname***\PROGRAM.DXC**.
- the *DT80* is reset. By default, the previously active job will be loaded (See *Startup Job* (P59))
- A USB memory device is inserted. If a file **A:\ONINSERT.DXC** or **A:***serialnum***\ONINSERT.DXC** is present then any commands therein will be executed. These may include a job definition, in which case the job will become the current active job. (See *ONINSERT Job* (P59))

Job Structure

A typical *DT80* job is shown below (the line numbers are for reference only and are not part of the job)

```
1       BEGIN"Boiler01"
2       ' No. 1 Boiler monitoring job for DT80  03-Dec-2005
3       /n/u/S/e
4       P22=44
5       Y10=4.5,0.312"kPa"
6       S1=0,50,0,100"L/m"
7       1DSO=0     ' Enable sensor power relay
8       RS5S
9
10      RB1M 2..3TT("Temp")
11
12      RC(DATA:NOV:365D)15M 1V(Y10,AV) 4#L(S1,AV)
13
14      RK10S
15       ALARM1(1V(Y10)>2.25)3DSO
16       ALARM1(4TT>110.0)3DSO,1CV"Over Temp ?"{RB5S}"
17
18      LOGON
19      END
```

Note the following salient points:

- Line 1 – the **BEGIN** command tells the *DT80* to clear the current job and prepare to receive a new one.
- Line 2 – anything following a single quote character (up to the end of the line) is considered a **comment** and is ignored. Blank lines are also ignored.
- Line 3-7 – the first part of a job normally consists of commands to set switches and parameters, define polynomials and spans, and evaluate any immediate channels.
- Line 8 – this line sets the scan rate for the statistical sub-schedule. All channels which include a statistical channel option, i.e. **1V(AV)** and **3#L(AV)**, will therefore be scanned every 5 seconds. The measured values will not be logged or returned; they will only be used for accumulating the average values.
- Line 10 – defines the B schedule (measure two thermocouples once per minute).
- Line 12 – defines the C schedule (report pressure and flow rate values, averaged over a 15 minute period. Note the use of a polynomial (**Y10**) to convert the measured voltage in mV to pressure in kPa. Similarly, a span is used to convert a current loop % value to a flow rate in l/m.)
- Line 14-16 – define the K schedule (every 10s check pressure and temperature against limits. If pressure exceeds 2.25kPa then set digital output 3 to LOW (active); if temperature exceeds 110°C then set digital output 3 to LOW, set 1CV=1, output and log an "Over Temp" alarm string, and change the scan rate of schedule B to 5s.)
- Line 18 – enables logging for all schedules (by default logging is disabled)
- Line 19 – marks the end of the job; all schedules will now be activated.

Job Commands

A number of commands are provided for managing jobs on the *DT80*.

Listing Job Names

The **DIRJOBS** command lists the names of all jobs stored in the *DT80* internal file system, e.g.

```
DT80> DIRJOBS
  FRED
 *GEORGE
+ RON
+ GINNY
  UNTITLED
```

An asterisk (*) indicates the currently active job, if any. Locked jobs are indicated by a plus sign (+).

The **CURJOB** command simply displays the name of the current active job, e.g.

```
DT80> CURJOB
GEORGE
```

Specifying Jobs

The following commands act on a specific job or jobs. To specify the job you can enter a *jobspec* parameter after the command, where *jobspec* can be either:

- a job name in double quotes, e.g. **"FRED"**, or
- an asterisk (*****), which will apply the command to all stored jobs, or
- nothing, in which case the command will operate on the current active job (an error message will be reported if there is no currently active job).

Showing Program Text

To show the commands which define a job, use **SHOWPROG***jobspec*, e.g.

```
DT80> SHOWPROG"RON"
Job Program - RON
BEGIN"RON"
RA1S 3TT 1DS
END
```

Locking Jobs

If a job is **locked** then its program text cannot be deleted or overwritten. To lock a job use the **LOCKJOB***jobspec* command; to unlock use **UNLOCKJOB***jobspec*, e.g.:

```
DT80> LOCKJOB*
Locking Job FRED - Done
Locking Job GEORGE - Done
Locking Job RON - already locked
Locking Job GINNY - already locked
Locking Job UNTITLED - Done
```

Deleting Jobs

The **DELJOB***jobspec* command can be used to delete a job from the *DT80*'s internal file system.

However, this command will fail and the job will not be deleted if any of he following apply:

- the job is the current active job and the **/F** (fix schedules) switch is set (use **/f** to turn this switch off)
- the job is locked (use **UNLOCKJOB** to unlock it)
- the job has logged data and/or alarms (use **DELDATA** and **DELALARMS** to delete them)

Managing a Job's Logged Data and Alarms

The following commands allow you to manage the data and alarms logged by a job:

- **LISTD** lists details of the number of logged records and the associated time range
- **COPYD** is used to **unload** data and/or alarms – that is: read data from one or more store files, transform it to the selected format (e.g. CSV), and output it to the currently active comms port, or a file, or an FTP server
- **DELD** will delete a job's logged data and/or alarms respectively.

For more details on these commands, see *Logging and Retrieving Data* *(P86)*.

Startup Job

The *DT80* can automatically load a user-defined job every time it is restarted by a hard reset (**HRESET** command or power failure or pressing the manual reset button). This allows the *DT80* to operate as a dedicated instrument.

The *DT80*'s behaviour following a hard reset is controlled by the following profile setting:

PROFILE STARTUP RUN

There are three possible settings for this profile:

- **CURRENT_JOB** – the *DT80* will reload the job that was active prior to the reset (if any). This is the default.
- **NONE** – no job will be loaded following hard reset
- *jobname* – the specified job (if it exists) will be loaded following hard reset.

If a "triple push" reset is performed (see *Safe Mode* *(P211)*) then the configured startup job will not be loaded.

ONINSERT Job

When a USB memory device is inserted into a *DT80*, the *DT80* first looks for a file on the USB device named **A:***serialnum***\ONINSERT.DXC**, where *serialnum* is the serial number of the *DT80* (e.g. **SN80322**). If found, the commands in this file are entered into the *DT80* exactly as if they had been received via a comms port.

If the above file is not found, the *DT80* looks for a command file in the root directory, i.e. **A:\ONINSERT.DXC**; if found it is loaded into the *DT80* in the same way.

If the USB device contains a suitable **ONINSERT.DXC** file, a prompt (**Run ONINSERT?**) will be displayed on the LCD to give you an opportunity to prevent it running. Press **OK** to immediately run the ONINSERT job, or any other key to prevent execution. If no key is pressed within 5 seconds then the ONINSERT job will be run.

This auto-programming function means that a single USB memory device can be inserted into a number of *DT80*s, one at a time, and either:

- automatically program all the *DT80*s with the same job — if no serial-number-specific subdirectories containing **ONINSERT.DXC** files exist on the USB device and an **ONINSERT.DXC** file exists at the root level, or
- automatically program particular *DT80*s with their own specific job — if serial-number-specific subdirectories containing **ONINSERT.DXC** files exist on the USB device, or
- carry out a combination of these two options — *DT80*s that do not find a subdirectory named with their serial number automatically load and run the "standard" **ONINSERT.DXC** file at the root level, and *DT80*s that find their specific subdirectory automatically load and run the "specific" **ONINSERT.DXC** file found there.

These files are typically created by inserting the USB memory device into a PC and copying the required program files to the required directories.

Alternatively, the *DT80* command:

RUNJOBONINSERT"*jobname***"**

can be used to copy the specified job's program text to **A:***serialnum***\ONINSERT.DXC**.

Similarly,

RUNJOBONINSERTALL"*jobname***"**

will copy the specified job's program text to **A:\ONINSERT.DXC**.

To delete the **ONINSERT.DXC** files from the inserted USB memory device, you can use the

DELONINSERT

and

DELONINSERTALL

commands.

Part E – Manipulating Data

Scaling

Most *DT80* channel types automatically scale measured values so that the returned values are in appropriate engineering units. For example, the thermocouple channel types (e.g. **TK**) automatically apply the appropriate scaling polynomial so that the data is returned in °C. However, a number of additional facilities are provided for applying custom scaling or corrections:

- channel factor
- spans
- polynomials
- thermistor scaling
- intrinsic functions
- expressions

Channel Factor

For many channel types, the channel factor (a channel option consisting of just a floating point number) can be used to provide a simple multiplication factor. See *A Special Channel Option — Channel Factor* *(P37)*.

For example, if a high voltage is being measured using an external 12.5:1 voltage divider then the following channel definition:

```
1V(12.5)
```

will multiply the raw reading by 12.5 so that the returned value reflects the actual voltage.

Note that for some channel types the channel factor performs a special function, and therefore cannot be used as a scaling factor. In these cases a span should be used (see below).

For example, if you are measuring a frequency which has passed through a 100:1 prescaler then you will need to use a span to scale it.

Spans (S*n*)

A span transforms a measured **signal** value (e.g. mV) into the corresponding **physical** value (e.g. kPa) using a straight line function:

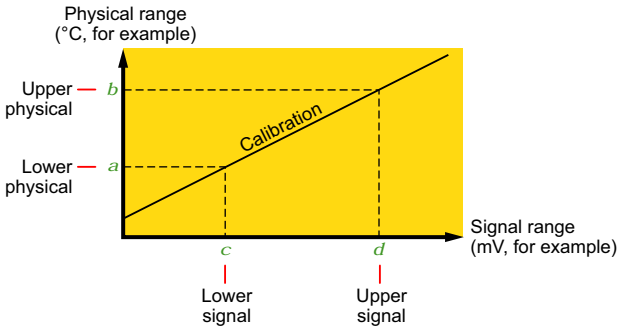


Figure 18: Span coordinates

A span must be **defined** before it is applied. This is normally done at the start of a job, before any schedules are defined. The syntax is as follows:

```
Sn=a,b,c,d"units"
```

where:

- *n* is the **poly/span number** (1 to 50), which is used simply to distinguish one span from another. Note that a span and a polynomial cannot have the same number.
- *a* and *b* are the **physical** coordinates of two points on the calibration line (reported or output values)
- *c* and *d* are the **signal** coordinates of two points on the calibration line (measured or input values). If not specified, 0 and 100 are assumed.
- *units* replaces the channel's default units text

Spans are particularly suited to 4–20mA current loop inputs. The following defines a span suitable for a current loop sensor that measures pressure in the range 0-300kPa:

```
S2=0,300"kPa"
```

Note that in this case the default signal coordinates (0 and 100) are used, because the **L** (current loop) channel type returns a value in the range 0-100%.

Once defined, a span may be **applied** to any number of channels in any schedules or alarms using the **S*n* channel option**.

In the following example, two of the above current loop pressure sensors are used, plus a frequency input which passes through a 10:1 prescaler (frequency divider):

```
BEGIN"MONKEY"
S1=0,10,0,1"Hz" ' multiply measured freq by 10
S2=0,300"kPa"   ' scale 0-100% to 0-300kPa
RA10S 1#L(S2,"Inlet") 2#L(S2,"Outlet") 4F(S1)
END
```

This will return data in the form:

```
Inlet 23.9 kPa
Outlet 119.0 kPa
4F 3920 Hz
```

Note that for the **F** channel type the channel factor indicates the sample period, so it cannot be used as a scaling factor. A span is therefore used instead.

A span can also be applied in reverse, using the **SR*n*** channel option. Thus

```
S1=0,100,32,212 1CV(S1)
```

is equivalent to

```
S1=32,212,0,100 1CV(SR1)
```

Polynomials (Y*n*)

Polynomials are used to define calibrations for non-linear sensors. Each defined polynomial can have up to six polynomial coefficients.

The *DT80* evaluates a polynomial according to the formula

$$y = k_0 + k_1 x + k_2 x^2 + k_3 x^3 + k_4 x^4 + k_5 x^5$$

where x is the raw channel reading, and the k's are coefficient terms.

A polynomial is defined in a similar way to a span:

Y*n*=*k0*,*k1*,*k2*,*k3*,*k4*,*k5*"*units*"

where:

- *n* is the **poly/span number** (1 to 50), which is used simply to distinguish one polynomial from another. Note that a span and a polynomial cannot have the same number.
- *k0* … *k5* are the polynomial coefficients. If not specified, a coefficient value of zero is assumed
- *units* replaces the channel's default units text

The required coefficients may be supplied by the sensor manufacturer, or they may be determined from a calibration curve or from measured data points using a least squares regression technique. Various statistical programs are available for this purpose.

Once defined, a polynomial may be applied to any number of channels using the **Y*n*** channel option. For example:

```
Y1=23.5,0,0.987"deg C"
RA1M 1V(Y1) 2V(Y1)
```

A "null" polynomial may also be used as a shortcut when defining several channels which all require the same custom units string, e.g.:

```
Y9=0,1"m/s"
RA10S 3CV(Y9) 5CV(Y9) 22CV(Y9) 33CV(Y9)
```

Thermistor Scaling (T*n*)

The *DT80* has channel types (e.g. **YS03**) for many 2-wire YSI thermistors (Yellow Springs Instruments). For other thermistor types, the *DT80* supports thermistor scaling — the conversion of a resistance reading to a temperature. The *DT80* does the conversion from resistance to temperature using

$$T = \frac{1}{a + b(\ln R) + c(\ln R)^3}$$

To apply thermistor scaling, firstly obtain the constant terms a, b and c from the thermistor manufacturer, then define a

thermistor conversion in a similar way to a polynomial or span:

T*n*=*a*,*b*,*c*"*units*"

where:

- *T* is the temperature, in Kelvin (K)
- *n* is the **thermistor conversion number** (1 to 20), which is used simply to distinguish one thermistor equation from another.
- *a, b, c* are the constants from the above thermistor equation. If not specified, a coefficient value of zero is assumed
- *units* replaces the channel's default units text

Once defined, a thermistor conversion may be applied to any number of resistance channels using the **T***n* channel option. For example:

```
T1=26.5,1.034,8.77e-3"K"
RA1M 3R(T1,"Solvent temp")
```

See also *Temperature – Thermistors* (P248).

Intrinsic Functions (F*n*)

The *DT80* has seven inbuilt and mutually exclusive intrinsic functions that may be applied as channel options. The intrinsic functions available are

F*n*	Description		Text Modifier
F1	1/x	inverse	(Inv)
F2	√x	square root	(Sqrt)
F3	Ln(x)	natural logarithm	(Ln)
F4	Log(x)	base ten logarithm	(Log)
F5	Absolute(x)	absolute value	(Abs)
F6	x * x	square	(Squ)
F7	Gray code conversion (16-bit)		(Gc)

The text modifier is appended to the channel's default units string. If a channel's units string has been explicitly set (using the "*name*~*units*" channel option) then no modifier is appended.

For example, the channel definition

```
1V(F2) 2F(F1,"period~sec")
```

will return data in the form:

```
1V 455.7 mV (Sqrt)
period 1.7 sec
```

Combining Scaling Options

The span (**S***n*), polynomial (**Y***n*), thermistor (**T***n*) and intrinsic function (**F***n*) channel options are all *mutually exclusive.* If more than one are specified then only the last one will be applied.

Channel variables and expressions (P64) can be used if multiple scaling operations need to be combined.

Calculations

Channel Variables (*n*CV)

Channel variables (CVs) are memory locations (registers) for holding and manipulating floating-point data. The *DT80* has 1000 channel variables, identified as **1CV** to **1000CV**.

All channel variables are reset to 0.0 when the *DT80* is reset (**HRESET**) or cleared (**INIT**).

Reading Channel Variables

A channel variable behaves in much the same way as any other channel type. Its value may be read (i.e. returned and/or logged) by including the appropriate *n***CV** channel definition in a schedule. For example, sending

```
12CV
```

will immediately return the value of channel variable #12, while

```
RA10S 1..5CV
```

will report the values of 1CV through 5CV every 10 seconds.

If a CV is being used for holding an intermediate value then you would normally use the **W** channel option to make it a working channel (which is not returned or logged).

Setting Channel Variables

A channel variable's value may be set in one of three ways:

- the CV is set to the value of an **expression**, i.e. *n***CV=***expression*
- any channel's value may be assigned to a channel variable by using the **=***n***CV channel option**
- certain special channel options (e.g. histogram) return multiple data values, which are written to a specified range of channel variables.

Some examples of using expressions to set CVs:

```
1..20CV=10.2        'initialise multiple CVs
RA1S 1V 9CV=9CV+1   'count the number of measurements taken
5CV(W)=3CV*SIN(21CV)+2CV*COS(21CV)
```

See also *Expressions* (P66).

The **=***n***CV** channel option allows a channel value to be assigned directly to a CV, typically so it can then be used in further calculations.

This can be used to apply a complicated linearisation equation, e.g.:

```
1V(=2CV,W) 2CV(S9,"temp~K")=2CV/(LN(2CV+1))
```

This will measure a voltage and assign it to 2CV (note the **W** option – we are not interested in logging/returning the raw voltage value). The value in 2CV is then plugged into the specified expression and the result stored back in 2CV. Finally a span (**S9**, which must have been previously defined) is applied and the result is returned with appropriate name and units.

An arithmetic operator may also be applied during the assignment, using the **+=***n***CV**, **-=***n***CV**, ***=***n***CV** and **/=***n***CV** channel options.

These allow a CV to be used as an accumulator, e.g.

```
RA1M 3C(+=2CV) 2CV("Total")
```

will report the number of counts received in each one minute period, plus the total counts, i.e.:

```
3C 192 Counts
Total 192

3C 77 Counts
Total 269
```

Note also that

```
1V(/=1CV)
```

is equivalent to

```
1V(=2CV) 1CV(W)=1CV/2CV
```

Storage Precision

Channel variables may be used to store values with magnitudes from 10^{-38} to 10^{38}. However, it is important to be aware that values are stored with 24 bits of precision, or approximately 7.25 significant digits when written in decimal form. This means

that whenever the *DT80* displays a value, it will only be accurate to 7 significant digits. The 8th digit can be used to distinguish values which are close together, but its value may be out by a few counts. Any changes in the 9th or later digits will not be reflected in the stored value.

This is particularly noticable when incrementing large integer values. For example:

```
1CV=3600000
RA1S 1CV=1CV+1
1CV 3600000.0
1CV 3600000.8
1CV 3600002.0
```

In this example 8 significant digits are being displayed, so the last one is not accurate. It would be better in this case to not display any decimal places, i.e. **1CV(FF0)=1CV+1**.

Once the magnitude of the CV value exceeds 2^{24} (16,777,216), adding one to it will no longer cause its value to change.

A consequence of this is that if you manually count something using a channel variable (e.g. **1CV=1CV+1**) then it will stop counting once its value reaches 16,777,216. Note that this only applies to manual counting using CVs – hardware and software counters (**HSC** and **C** channel types) can count over the full 32-bit range.

If you need a CV to count beyond 16,777,216 then you will need to use two CVs to hold the count value, e.g.:

```
1CV=1CV+1 IF(1CV>1000000){2CV=2CV+1 1CV=0}
```

Naming Channel Variables

As with any other channel type, **CV** channels can be given name and units strings using the **"***CVname*~*Units***"** channel option.

The command

```
NAMEDCVS
```

will return a summary of all CVs that have been explicitly named, e.g.:

```
 CV S  CV Name                Value  Units
=========================================
  5 A  Temp                   89.1   Deg C
  1 A  Speed                  23.4   m/s
```

(The "S" column is the schedule identifier)

Calculation Only Channels

If you need to return a calculated value then a channel variable is often used, e.g.

```
9CV("sum")=1CV+2CV+3CV
```

However, if you are just logging the result of this expression, and are not going to do any further calculations with it, then there is no point storing the result in **9CV**.

The **CALC** channel type is a better choice here. An expression can be assigned to it, and the result will be logged in exactly the same way as a CV. The only difference is that it does not actually copy the result to any particular channel variable.

For example:

```
CALC("sum")=1CV+2CV+3CV
```

Reference Channels

A **reference channel** is used to reference the value of another channel, which is identified by name. In this way a measurement can be used is multiple places without having to assign it to a channel variable.

To define a reference, use an ampersand followed by the name of the channel whose value you wish to reference, i.e. **&***channel*. For example:

```
RA1S 1V &1V
```

In this (not very useful) example a voltage is measured once but reported twice – once by the original channel and once by the reference to the channel.

Names

If the "source" channel has a user-defined name then it must be used when defining a reference, e.g.

```
RA1S 1V("Voltage12") &Voltage12
```

If the source channel's name has spaces or special characters (anything other than A-Z, 0-9, or _) then it should be enclosed in quotes, e.g.

```
RA1S 1V("Voltage no. 12") 1+TK   &"Voltage no. 12" &"1+TK"
```

Note that name comparisons are not case sensitive, so **&BIG** is a valid reference to **1R("big")**.

If there is more than one source channel with the same name (a practice that is not recommended) then the reference will refer to the first one defined. e.g.

```
RA1S 1V("a") 1R("a") &a
```

defines a reference to the voltage, not the resistance.

Options

A reference channel is a channel in its own right so, like any other channel, it can have its own channel options. However, because a reference channel does not physically measure anything, sampling options will not be applicable. It can have reporting options, e.g.

```
RA1S 1V("Voltage12") &Voltage12(Y1,"Pressure12~kPa")
```

In the above example a voltage based pressure sensor is sampled. Both the raw voltage and the pressure (calculated by applying polynomial **Y1**) are returned.

Reference channels inherit their data type (integer or floating point) and default units from the source channel. For example:

```
1C &1C
1C 210 Counts
&1C 210 Counts
```

The reference channel's units can of course be overridden:

```
1C &1C("~Woozles")
1C 210 Counts
&1C 210 Woozles
```

Sampling

For a reference channel that is included in a schedule, the source channel must be defined somewhere in the job. The source channel does not need to occur before the reference to it, but it must be somewhere between the **BEGIN** and **END**.

References can be used in the immediate schedule, but in this case the source channel must precede the reference, and it must be on the same command line.

If the source channel has not been sampled at the time that the reference channel is sampled then the reference channel's value will be NotYetSet.

Note also that references are read-only; an expression can not be included, e.g.

```
&1CV=1 'error
```

Expressions

References can be included in expressions. For example:

```
1CV=(&1TK+&2TK)/2
```

will calculate the mean of two previously sampled temperatures.

Examples

Some of the applications of reference channels are listed below. Many of these could also be done using channel variables, but using references is generally clearer and more efficient.

Same reading scaled two ways

The following will log the same reading in both degrees Celsius and Fahrenheit

```
S1=32,212,0,100"degF" 1TK(FF2) &1TK(S1,FF2)
```

Multiple statistics from the same raw data

The following will calculate two different averages from the same raw data

```
RS1S RA10S 1TK(W)(AV,"10s_ave") RB1M &1TK(AV,"1min_ave")
```

Testing one reading in multiple alarms

In this example a temperature is sampled once but then tested in three different alarm conditions.

```
1TK("indoor")
IF(&indoor<19)"too cold^M^J"
IF(&indoor><19,27)"nice^M^J"
IF(&indoor>27)"too hot^M^J"
```

Manually Poll Most Recent Sample

References allow you to make an ad hoc query for the most recent value of a channel that is being regularly sampled.

```
BEGIN"zoo" RA1M 1TK END
&1TK
```

Expressions

The *DT80* has a powerful expression evaluation capability, allowing measured values to be manipulated using a variety of mathematical and logical operations.

An **expression** consists of one or more **operands** which are manipulated using **operators** to produce a numeric **result**. The result of an expression can be assigned to any of the channel types identified as "writable" in the table of channel types *(P30)*. Expressions cannot contain any spaces.

Operands

An expression operand can be either

- a numeric constant, e.g. **27** or **-2.95** or **2.222e-6** or **0x3fff** (hexadecimal)
- one of the special constants **PI** (3.1415927) or **E** (2.7182818)
- a channel variable, e.g. **17CV**
- a reference to another channel, e.g. **&1TK** or **&"Reactor Temp"**
- a sub-expression in parentheses, e.g. **(1CV+1)** or **(COS(D2R(3CV))+1)**. The sub-expression will be evaluated first and the result will become the operand.

Operators

The following operators are supported. In the following table *x* and *y* can be any of the operand types listed above.

Operator	Description	Type
x+*y*	addition	*
x-*y*	subtraction	*
*x***y*	multiplication	*
x/*y*	division	F
x^*y*	*x* raised to power *y*	F
x%*y*	*x* modulo *y* (remainder after division)	*
x<*y*	1 if *x* less than *y*, otherwise 0	I
x<=*y*	1 if *x* less than or equal to *y*, otherwise 0	I
x>*y*	1 if *x* greater than *y*, otherwise 0	I
x>=*y*	1 if *x* greater than or equal to *y*, otherwise 0	I
x=*y*	1 if *x* equals *y*, otherwise 0	I
x!=*y*	1 if *x* equals *y*, otherwise 0	I
*x*AND*y*	1 if *x* is non-zero and *y* is non-zero, otherwise 0	I
*x*OR*y*	1 if *x* is non-zero or *y* is non-zero, otherwise 0	I
*x*XOR*y*	1 if *x* is non-zero or *y* is non-zero but not both, otherwise 0	I
-*x*	negative *x*	*
NOT*x*	1 if *x* is non-zero, otherwise 0	I
ABS(*x*)	absolute value of *x*	*
SQRT(*x*)	square root of *x*	F
LOG(*x*)	base 10 logarithm of *x*	F
LN(*x*)	base e logarithm of *x*	F
SIN(*x*)	sine of *x* (*x* is in radians)	F
COS(*x*)	cosine of *x* (*x* is in radians)	F
TAN(*x*)	tangent of *x* (*x* is in radians)	F
ASIN(*x*)	arcsine of *x* (result is in radians)	F
ACOS(*x*)	arccosine of *x* (result is in radians)	F
ATAN(*x*)	arctangent of *x* (result is in radians)	F
S*n*(*x*)	apply span #*n*	F
SR*n*(*x*)	apply reversed span #*n*	F
Y*n*(*x*)	apply polynomial #*n*	F
T*n*(*x*)	apply thermistor scaling #*n*	F
F*n*(*x*)	apply intrinsic function #*n*	F
D2R(*x*)	*x* / 57.29576 (convert degrees to radians)	F
R2D(*x*)	*x* * 57.29576 (convert radians to degrees)	F

Data Types

Integers and Floating Point

DT80 channels can return either a 32-bit integer or a 32-bit floating point value. Digital and counter channels return an integer value; most other channel types return floating point values.

The **Type** column in the above table indicates the data type that results from applying the specified operator. Operators marked **F** always result in a floating point value, operators marked **I** result in an integer, and operators marked ***** result in a floating point value if either of their operands is a floating point value. Note that a numeric constant is considered to be an integer unless it has a decimal point or exponent.

Note however that channel variables can only hold floating point values. Thus if an expression result is assigned to a channel variable then it will always be converted to a floating point value. This is not the case for a **CALC** channel, which can return either an integer or a floating point value.

Error Values

If an operand has an error value (e.g. overrange) then the result of any operator will also be an error value. For example,

```
CALC=&1V/1000
```

will return a value of `OverRange` if the original **1V** measurement that is being referenced in the expression was overrange.

Operator Precedence

Each operator is assigned a **precedence level**, as follows:

Precedence Level	Operators
1 (highest)	**-** (negative)
2	**^**
3	*****, **/**, **%**
4	**+**, **-** (subtract)
5	**<**, **<=**, **=**, **!=**, **>=**, **>**
6 (lowest)	**AND**, **OR**, **XOR**, **NOT**

When an expression contains more than one operator then the operator with the highest precedence is evaluated first. If the operators have equal precedence then they are evaluated left to right. Parentheses may be used to create sub-expressions and thereby alter the order of evaluation.

Examples

Equal precedence operators are evaluated left to right:

```
3CV=7-2+3          '3CV = 8 (not 2)
```

Changing evaluation order using parentheses:

```
4CV=1.5+2*3^2      '4CV = 19.5
4CV=(1.5+2)*3^2    '4CV = 31.5
4CV=((1.5+2)*3)^2  '4CV = 110.25
```

Negative and subtract operators are different:

```
2CV=-5^2           'negative: 2CV = 25
2CV=0-5^2          'subtract: 2CV = -25
```

Logical Expressions

Boolean logic within expressions can be used to return a result that is dependent on a condition being true (1) or false (0), e.g.

```
2CV=(1CV*2*(1CV<1000))+(1CV*4*(1CV>=1000))
```

returns a value of **1CV*2** if 1CV is less than 1000, or a value of **1CV*4** if 1CV is greater than or equal to 1000.

Combining Methods

The different scaling and calculation methods can be used together. The following comprehensive examples are the best way to demonstrate.

Example 1

In this program, a vector average is calculated. The inputs are wind speed and direction.

```
BEGIN"Wind-01"

'Wind speed calibration 0-50m/s = 0-1000mV
S1=0,50,0,1000"m/s"
'Wind direction 0-2Pi radians (0-360deg) = 0-1000mV
S2=0,6.2832,0,1000"radians"
Y3=0,1"m/s" 'Units text for wind speed report
Y4=0,1"Deg" 'Units text for wind direction report

RA5S 'Schedule to scan every 5 seconds
 1V(S1,W) 'Sample wind speed
 2V(S2,W) 'Sample wind direction
 3CV(W)=3CV+&1V*COS(&2V) 'Sum x components
 4CV(W)=4CV+&1V*SIN(&2V) 'Sum y components
 5CV(W)=5CV+1 'Number of scans

RB1M 'Calculate, report and log every minute
 'Calculate mean magnitude:
 6CV(W)=SQRT((3CV*3CV)+(4CV*4CV))/5CV
 6CV("Mean Wind Magnitude",Y3,FF1)
 'Calculate direction
 7CV(W)=R2D(ATAN(4CV/3CV))
 'Determine direction quadrant
 7CV(W)=7CV+((3CV>0)AND(4CV<0))*360
 7CV(W)=7CV+((3CV<0)AND(4CV<0))*180
 7CV(W)=7CV+((3CV<0)AND(4CV>0))*180
 'If wind speed is zero, return -1.0:
 7CV(W)=7CV-(6CV<=0)*(7CV+1)
 7CV("Mean Wind Direction",Y4,FF0)
 1..5CV(W)=0

LOGON
END
```

Example 2

This program scans ten channels and calculates a cross-channel average.

```
BEGIN"Wind-02"
RA10S
 1CV(W)=0 'Clear 1CV
 1..10V(+=1CV,W) 'Sum 10 voltages into 1CV
 1CV=1CV/10 'Divide by 10 for average
END
```

Derived Quantities

The *DT80* can automatically compute various commonly used **derived quantities** such as differences, rates of change, pulse widths and so on. These are calculated by including the appropriate channel option, as detailed below.

In each case the derived quantity is returned instead of the original reading.

Rates and Integrals

The following derived quantities are calculated based on the current and the previous channel reading.

Channel Option	Description	Formula
DF	Difference	Δx
DT	Time difference	Δt
RC	Rate of change	Δx / Δt
RS	Reading / time difference	x / Δt
IB	Integrate	(x – Δx / 2) Δt

The **DF** channel option returns the **difference** between the current and previous measurements; the **DT** option returns the **time difference** and the **RC** channel option combines the two to return the **rate of change** (Δx / Δt).

For example,

```
RA1S 1V(=1CV) 1CV(DF,"DeltaV") 1CV(DT,"DeltaT") 1CV(RC,"RC~mV/s")
1V 29.4 mV
DeltaV 3.9
DeltaT 00:00:00.992 0
RC 4.0 mV/s
```

In this case four channels are defined in the schedule. The first will measure a voltage, return the reading, and assign it to 1CV. The second channel will compare the newly updated value of 1CV to the value it had when the channel was last evaluated (one second ago) and return the difference. Similarly the third and fourth channels will return the time difference (which will in this case always be close to one second) and rate of change, respectively.

The **RS** option is similar to **RC** except that the numerator is the actual reading, not the difference. This is intended for use with channels where the reading is already a difference. In the following example the counter is reset after each reading (using the **R** channel option), so the count reading is actually the number of counts since the last reading, so to calculate counts per second the **RS** option is used:

```
RA10S 3C(R,RS,"~counts/s")
```

Finally, the **IB** option is used to **integrate** a signal. It returns the area under a straight line connecting the current to the previous reading. For example:

```
RA20S 1V(=1CV,W) 2#I(=2CV,W)
  3CV("Power~W",=4CV)=1CV*2CV
  4CV(IB,W,+=5CV)
  5CV("Energy~J")
```

The above example will, every 20 seconds, first measure a voltage and a current and assign them to two channel variables. These are then multiplied to give the instantaneous power in Watts (3CV), then integrated to give the energy used over the 20 second period (4CV). Finally, the energy values are accumulated in channel variable 5CV to give the total energy used.

Edge Timing

A number of channel options are provided for reporting details relating to the timing of digital transitions (edges).

As with the rate and integral options, these derived quantities are calculated based solely on the current and the previous channel readings.

The **TOR** and **TOF** options return the absolute date/time at which a last rising or falling edge occurred. If no edge has occurred since the last reading then a "zero" date/time value (normally presented as `00:00:00.000,01/01/1989`) is returned.

The following options report the time interval between two edges:

- If a rising edge has occurred since the last reading on a channel, and another rising edge has occurred some time previously, then the **TRR** option returns the time interval between the two edges, otherwise it returns zero.
- If a rising edge has occurred since the last reading on a channel, and a falling edge has occurred some time previously, then the **TFR** option returns the time interval between the two edges, otherwise it returns zero.
- If a falling edge has occurred since the last reading on a channel, and another falling edge has occurred some time previously, then the **TFF** option returns the time interval between the two edges, otherwise it returns zero.

- If a falling edge has occurred since the last reading on a channel, and a rising edge has occurred some time previously, then the **TRF** option returns the time interval between the two edges, otherwise it returns zero.

For example:

```
RA1E 1DS 1DS(TOF,"-edge at") 1DS(TFF,"period")
1DS 0 State
-edge at 15:30:35.015 01/02/2007
period 00:00:00.000 0

1DS 1 State
-edge at 00:00:00.000 01/01/1989
period 00:00:00.000 0

1DS 0 State
-edge at 15:30:45.018 01/02/2007
period 00:00:10.003 0

1DS 1 State
-edge at 00:00:00.000 01/01/1989
period 00:00:00.000 0
```

In the above example the A schedule runs when a rising or falling edge on digital input 1 occurs, and reports the time at which each falling edge occurs, as well as the time between successive falling edges (i.e. the period).

Note that it is not possible to set the schedule to only trigger on falling edges (using **RA1-E**), because then the state of 1DS would be zero each time the schedule ran. This would mean that no falling edges (i.e. current value = 0, previous value = 1) would be detected.

Statistical Channel Options

Overview

It is often convenient to sample channels frequently and a return and/or log a **statistical summary** at longer intervals (see Statistical Report Schedules *(P52)*). Statistical channels are sampled during the period between report times (at a rate governed by the statistical schedule, **RS**), and the statistical summary is generated and returned at report time, i.e. when the regular schedule runs.

Channels that require statistical sampling must include a channel option to indicate the statistical information to generate. Here's a summary of the statistical channel options — see also the Statistical *(P42)* category in the *Table 4: DT80 Channel Options* *(P43)* table:

Channel Option	Description	Appended to Units
AV	Average	(Ave)
SD	Standard deviation	(SD)
MX	Maximum	(Max)
MN	Minimum	(Min)
TMX	Time of maximum	(Tmx)
TMN	Time of minimum	(Tmn)
DMX	Date of maximum	(Dmx)
DMN	Date of minimum	(Dmn)
IMX	Instant of maximum (combines DMX and TMX)	(Imx)
IMN	Instant of minimum (combines DMN and TMN)	(Imn)
INT	Integral	(Int)
NUM	Number of samples	(Num)

The statistical option is defined by including it as a channel option in parentheses after the channel type. For example:

```
RA1M 3TT(AV)(NUM)
3TT 103.7 degC (Ave)
3TT 42 (Num)

3TT 110.2 degC (Ave)
3TT 60 (Num)
```

In this case you will see the **Sample** LED flash once per second (which is the default rate for **RS**), but data will only be returned once per minute. These data consist of average of the samples taken since the A schedule last ran, and the number of samples (which will normally be 60). Note that a tag, e.g. (Ave), is attached to the units to indicate the statistical function that has been applied.

Note There may be fewer than expected samples in the first sample period after starting a schedule. This is because, by default, schedule execution is synchronised to midnight (see *Time Triggers — Synchronizing to Midnight* (P54)) so a one minute schedule will always execute on minute boundaries.

If insufficient statistical samples have been taken at the time when the report schedule runs then an error message returned and the data value is flagged as "not yet set". The **SD** and **INT** options require a minimum of two samples, the others require at least one sample. To minimise the chance of this condition occurring:

- switch off the synchronise to midnight flag (**/s**), or
- ensure that the reporting schedule period is substantially longer than the statistical schedule period.

Statistical Functions

Average (AV)

The average or mean is the sum of all the channel readings divided by the number of readings. It is very useful in reducing sensor noise.

Standard Deviation (SD)

Standard deviation is a measure of the variability of the data about the average or mean. The variation may be due to electrical noise or process changes. The units of standard deviation are the same as the channel reading.

Maximum and Minimum (MX and MN)

The maximum and minimum of a set of channel readings can be reported with the **MX** and **MN** channel options.

The time at which these occurred can be reported with the **TMX** and **TMN** options, the date with **DMX** and **DMN**, and the combined date/time ("instant") with the **IMX** and **IMN** channel options.

For example:

```
RS1M  RA30M 1TK(AV)  RB1D 1TK(MX)(TMX)(MN)(TMN)
1TK 24.2 degC

1TK 21.9 degC

1TK 19.0 degC
1TK 33.9 degC (Max)
1TK 15:10:00.000 (Tmx)
1TK 12.9 degC (Min)
1TK 04:33:00.000 (Tmn)
```

The above job measures the temperature once a minute (**RS1M**). Every 30 minutes the average for the 30 minute period is returned by the A schedule. Once a day (at midnight), the daily min/max temperatures are returned, along with the times at which they occurred.

Integration (INT)

The integration channel option returns the integral (area under the curve) with respect to time in seconds using a trapezoidal approximation. The units of an integration are those of the original reading multiplied by seconds.

In the following example a sensor returns a voltage that is proportional to the flow rate (0-1000mV = 0-0.2 l/s):

```
BEGIN
RS100T
S5=0,0.2,0,1000"litres"
1CV=0
RA2S 1V(S5,INT,+=1CV,W) 1CV("Fuel Used",FF3)
END
Fuel used 0.012 litres

Fuel used 0.104 litres
```

Every 100ms, the voltage output from the sensor is measured, scaled by span **S5** (yielding a value in litre/s) and the integral is progressively accumulated (yielding a value in litres). This is then accumulated in **1CV** (yielding the total number of litres used since the schedule started), which is reported every 2 seconds.

Note the differences between the **INT** and **IB** options (both of which calculate integrals):

- The **IB** option uses two points only (the current value and the previous value) and calculates the area under the curve using a single trapezoid. It does not involve the statistical schedule.
- **INT** is a statistical option. It calculates the integral using a trapezoid for each sample point measured by the statistical schedule.

Multi Value Statistical Options

The statistical options described here are special in that they return **multiple values**. A channel can only have one return value, so these options work by setting channel variables.

These channel options do not affect the usual reporting or logging of the channel's readings.

Histogram (*Hx:y:m..nCV*)

The *DT80* can be used to generate a histogram (frequency distribution) of channel samples by applying the histogram channel option, which instructs the *DT80* to

- divide the measured data range into a number of intervals called **classes**
- count the number of readings that occur in each class during the histogram period
- load each class count into a separate channel variable.

Then use another schedule to read, log and clear the channel variables.

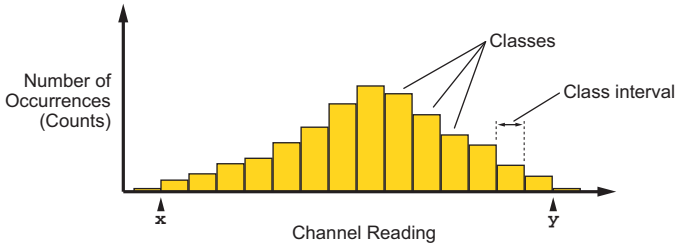


Figure 19: Histogram

In addition, the *DT80* automatically counts the number of under-range, over-range and total readings, and stores these in three separate channel variables.

The format of the histogram channel option is:

H*x*:*y*:*m*..*n***CV**

where:

- *x* and *y* are the lowest and highest channel readings of interest, as shown in the above diagram
- *m* and *n* denote the range of channel variables (*m***CV** to *n***CV** inclusive) to use for storing count values.

The channel variables are set as follows:

Channel Variable	Function
*m***CV**	number of readings in the lowest class
...	
*(n-3)***CV**	number of readings in the highest class
*(n-2)***CV**	number of readings under range (<*x*)
*(n-1)***CV**	number of readings over range (>*y*)
*n***CV**	total number of readings including those out of range

The range *x..y* will therefore be broken up into (*n* – *m* – 2) classes.

Example — Histogram

To create a histogram of a temperature channel over five classes requires eight channel variables:

```
BEGIN"HISTO"
11..18CV=0
RA1S 1TT(H25.0:35.0:11..18CV)
RBX 16CV("Under") 11..15CV 17CV("Over") 18CV("Total")
RCX 11..18CV=0
END
```

The A schedule will report the temperature once a second. It will also accumulate a histogram with five temperature classes and intervals of 2°C:

- **11CV** counts readings in the first class (25.0 to 26.999°C interval)
- **12CV** counts readings in the second class (27.0 to 28.999°C interval)

- **13CV** counts readings in the third class (29.0 to 30.999°C interval)
- **14CV** counts readings in the fourth class (31.0 to 32.999°C interval)
- **15CV** counts readings in the fifth class (33.0 to 34.999°C interval)

The following three CVs will also be updated:

- **16CV** is the number of under-range samples (<25°C)
- **17CV** is the number of over-range samples (>35°C)
- **18CV** is the total number of samples (sum of 11..17CV)

The B schedule will, when polled, report the current histogram data. Polling the C schedule will clear the histogram data. A typical histogram report would look like:

```
XB
Under 7
11CV 19
12CV 33
13CV 102
14CV 71
15CV 22
Over 2
Total 246
```

Rainflow Cycle Counting

Rainflow cycle counting (also called **rainflow analysis**) is an internationally-accepted method of fatigue cycle counting used for monitoring long-term accumulative structural fatigue damage. The process reduces large quantities of cyclic data — collected from sensors attached to the structure over a long period of time — into relatively simple histograms.

As a structure deflects due to repetitive external influences, measurements produce arbitrary peak and valley sequences that form closed loops or cycles. Each loop or cycle has a size (the difference between peak and valley magnitudes), and rainflow analysis accumulates a profile of the number of cycles versus cycle size into a histogram.

A minimum cycle size can be defined that sets a noise rejection level, and cycle sizes below this level are rejected as noise and are not counted.

The *DT80* implements the ASTM E 1049-85 standard: Standard Practices for Cycle Counting in Fatigue Analysis.

Real-time rainflow analysis can be carried out using the *DT80*'s **RAINFLOW** channel option, which instructs the *DT80* to monitor attached strain gauges at regular intervals and reduce the resulting large quantity of data into simple cycle histograms.

The *DT80* can also produce a formatted report of the accumulated cycle histograms — see Reporting Rainflow Data *(P74)*.

Although the rainflow cycle counting has been optimized for welded steel structures, it can be used to record arbitrary waveforms from other sources — temperature cycles in a furnace or electrical signals, for example.

Collecting Rainflow Data

Rainflow analysis is defined by the **RAINFLOW** channel option. Although this is generally used for channels measuring strain gauge inputs, you can also use it for any type of sensor that is monitoring a process that produces cycles of peaks and valleys with hysteresis.

The overall range of cycle sizes is divided into a number of smaller cycle size **classes** and, as the analysis proceeds, the number of cycles of each size class is counted. These counts are accumulated into the *DT80*'s 32-bit signed **Integer Variables** (channel type *n***IV**).

(These integer variables are only for use with rainflow analysis.)

The **RAINFLOW** channel option requires a maximum cycle size to be specified, a noise rejection level, and a range of sequential integer variables or channel variables that can be used for accumulating the cycle size counts and other information. It has the form:

RAINFLOW:*a*:*b*:*c*..*d***IV**

where:

- *a* is the **maximum cycle size** expressed in the channel type units (for example, ppm)
- *b* is the **minimum cycle size** for noise rejection expressed as a percentage of *a*
- *c* and *d* denote the range of integer variables (*c***IV** to *d***IV** inclusive) to use for storing count values.

Therefore the range of cycle sizes is from zero to the maximum cycle size defined (*a*), and cycle sizes smaller than *b*% of *a* are rejected and not counted. For example, the channel option

(RAINFLOW:1000:5:*c*..*d***IV)**

sets the cycle size range to 0–1000 units, and cycle sizes less than 50 (5% of 1000) units are rejected as noise.

The number of variables allocated for the rainflow analysis must be set to the number of cycle size classes required over the cycle size range, plus seven (7) additional variables for summary data. For example, if you require 10 cycle size classes over the cycle size range then 17 variables will be needed. The variables can begin at any number in their range of 1 to 500 (*c*), and are used sequentially to the last variable number (*d*).

The use of variables in the allocated variable range is summarized in the following table. The first column shows how variables are used within the allocated range, and the last column shows how 20 variables are used. The last 7 variables contain various summary data.

	c..*d*IV	IV Contents	Example: 21..40IV
	c+0	Contains the count of cycles for the first cycle size class	21IV
	c+1	Contains the count of cycles for the second cycle size class	22IV
	c+2	Contains the count of cycles for the third cycle size class	23IV
	⇓	⇓	⇓
	d–7	Contains the count of cycles for the last cycle size class	33IV
Summary data	*d*–6	Contains the count of cycles that over-ranged the maximum cycle size	34IV
	d–5	Contains the count of all cycles	35IV
	d–4	Contains the maximum buffered cycles 0..100 (or 99999 if the buffer has overflowed and buffered half-cycles have been lost)	36IV
	d–3	Contains the minimum valley encountered	37IV
	d–2	Contains the maximum peak encountered	38IV
	d–1	Contains the total number of good points	39IV
	d–0	Contains the total number of "in error" points (out of range, for example)	40IV

In practice, some cycles do not close immediately and are buffered until a closure is detected. Variable *d*–4 contains a count of these unclosed or "half cycles".

Note: The rainflow channel option can be used on a maximum of 16 channels.

Rainflow cycle data is collected at a rate dependent on the frequency of influences deforming the structure under test. These might be quite slow events (such as waves crashing against a sea wall), or quite fast (such as a high speed boat hull travelling through waves).

Place the channel being sampled for rainflow in a schedule that's triggered fast enough to take sufficient readings during a cycle to adequately characterise the loop closures. For example, the schedule

```
RA50T 3BGI(RAINFLOW:a:b:c..dIV,W)
```

measures the input every 50ms (20 times/sec), and counts loop closures. The **W** channel option declares this as a working channel (does not return or log the individual samples of strain-stress.

Reporting Rainflow Data

Rainflow data is collected over long periods of time using the **RAINFLOW** channel option. Then, periodically, the rainflow cycle histogram can be retrieved by a computer, using the **RAINFLOW** command.

To report the rainflow cycle histogram, send the original rainflow channel option exactly as originally defined for the channel, but as a command. That is, send the command:

```
RAINFLOW:a:b:c..dIV
```

The *DT80* returns a tabular report as illustrated below:

```
RAINFLOW:72:5:1..27IV
Rainflow ( 5% rejection)   01/01/2000 00:03:43
n    IV/CV  Range       Mean        Cycles
=============================================
  1      1          0.0         0.0          0
  2      2          3.6        11.4         27
  3      3          7.2        11.3          6
  4      4         10.8        12.4          6
  5      5         14.4        11.9          6
  6      6         18.0        12.8          9
  7      7         21.6        12.3          2
  8      8         25.2         0.0          0
  9      9         28.8         0.0          0
 10     10         32.4         0.0          0
 11     11         36.0        18.0          1
 12     12         39.6         0.0          0
 13     13         43.2         0.0          0
 14     14         46.8         0.0          0
 15     15         50.4         0.0          0
 16     16         54.0         0.0          0
 17     17         57.6         0.0          0
 18     18         61.2         0.0          0
 19     19         64.8         0.0          0
 20     20         68.4         0.0          0
 21     21   >=    72.0         0.0          0
```

```
================================================
Total cycles                                    58
Peak/Valley mean                              12.6
Max Peak                                        71
Min Valley                                      -1
Max buffered cycles                             11
Valid input points %                        100.00
```

The rainflow report provides a complete summary of the rainflow data for the collection period. The cycle size range for each class, the number of cycles in each class, and the mean for each class is shown, as well as the summary data.

Although the rainflow report cannot be logged in the *DT80*, the primary cycle count data used to make up the rainflow report can. For example, the program

```
BEGIN"Rainflow"
RA50T 2BGI(RAINFLOW:72:5:1..27IV,W)
RB7D 1..27IV
LOGONB
END
```

logs the histogram data every 7 days. Reports can be created manually after download of the primary cycle count data.

Example — Rainflow Cycle Counting

Capture raw strain gauge data and perform rainflow cycle analysis using the program

```
BEGIN
RA50T 1BGI(RAINFLOW:1000:5:101..127IV,W)
END
```

This instructs the *DT80* to

- collect current-excited bridge data (**1BGI**) every 50ms (**RA50T**) and carry out rainflow analysis over the range of zero to **1000** ppm
- apply a **5**% rejection (that is, cycles smaller than 50ppm are rejected)
- accumulate cycles into histogram variables 101 through 127 (**101..127**); this gives 20 cycle size classes for cycle counts, and 7 others for summary information.

The matching rainflow report command

```
RAINFLOW:1000:5:101..127IV
```

can then be used to return a summary report.

Part F – Alarms

Alarm Concepts

DT80 **alarms** allow decisions to be made based on the magnitude of *DT80* input channels, channel variables, timers, the clock/calendar, internal channels, system variables and so on. The decision is a **true** or **false** result of an alarm **condition test**. The true/false result is also known as the alarm **state**.

The *DT80* can be instructed to carry out actions when an alarm tests true. These actions can be setting the *DT80*'s digital state outputs, issuing messages, or executing commands to change the *DT80*'s operation.

Alarm transitions can also be logged to the *DT80*'s internal file system for later analysis.

There are two types of alarms:

- single shot alarms (**ALARM** command) act once on the transition of the condition test from false to true
- repeating alarms (**IF** and **DO** commands) act repeatedly each time the enclosing schedule runs, while the condition tests true

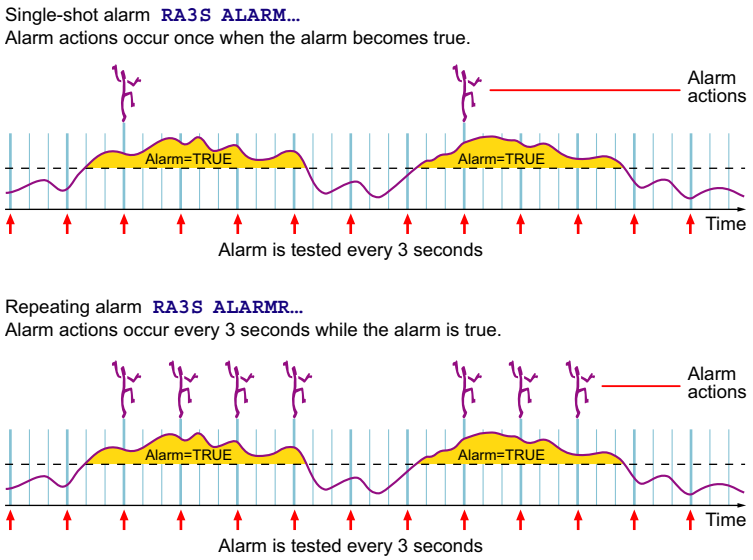


Figure 20: Comparing single-shot and repeating alarms (3-second schedule example)

Alarm commands can be included in any report schedule, and are processed in sequence with other schedule processes such as reading input channels and performing calculations.

Alarm Commands

The *DT80* provides three main alarm commands, each with a similar basic syntax:

ALARM*n* **(***test***)** *digitalAction* **"***actionText***" {***actionProcesses***}**

IF*n* **(***test***)** *digitalAction* **"***actionText***" {***actionProcesses***}** (**ALARMR** is also accepted as a synonym for **IF**.)

DO*n* **"***actionText***" {***actionProcesses***}**

where:

- ***n*** is the **alarm number**, used to distinguish logged alarms (optional)
- ***test*** is the **alarm condition** to test
- ***digitalAction*** is one or two digital output or CV channels which will follow the alarm state (optional)
- **"*actionText*"** is a text string to output if the alarm condition tests true (optional)
- **{*actionProcesses*}** is a set of channel definitions and/or commands to be executed if the alarm condition tests true (optional)

These are explained further in the following sections.

Note that the **DO** command is the same as **IF** except that the alarm condition is assumed to be always true.

Alarm Number

Alarm commands can optionally be given a number (1-255), which is used to identify the alarm when an alarm transition is logged.

For example:

```
RA1S ALARM1(2TT<15)"Too cold" ALARM2(2TT>30)"Too hot" LOGON
```

will test a temperature once per second. If the temperature dips below 15°C an alarm record indicating that alarm #1 has triggered will be logged to the *DT80*'s internal file system. See *Logging and Retrieving Data* *(P86)* for more details about the logging of data and alarms.

Alarm numbers need not be allocated in order, and they need not be unique (although normally they would be) – whatever you select as the alarm number will be what is logged if the alarm is triggered.

Note that unnumbered alarms, e.g.:

```
IF(1CV>10){9CV=9CV+1}
```

are not logged, even if logging is enabled for the schedule

Alarm Condition

The alarm condition compares a channel value to one or two **setpoints**. The state of the alarm is then set to true or false based on this test. (Note that in the case of the **DO** command, no alarm condition is specified – the state of the alarm is always true.)

Six different types of test are supported:

Condition	Alarm is true if
(*chan*==*setpoint*)	channel value is equal to *setpoint*
(*chan*!=*setpoint*)	channel value is not equal to *setpoint*
(*chan*<*setpoint*)	channel value is less than *setpoint*
(*chan*>*setpoint*)	channel value is greater than or equal to *setpoint*
(*chan*><*setpoint1*,*setpoint2*)	channel value is greater than or equal to *setpoint1* AND less than *setpoint2* (that is, between the two setpoints)
(*chan*<>*setpoint1*,*setpoint2*)	channel value is less than *setpoint1* OR greater than or equal to *setpoint2* (that is, outside the setpoint range)

where:

- ***chan*** is a standard channel definition, which will be evaluated (i.e. measured) in the usual way. One set of channel options may be included if required. If the channel is being assigned from an expression then the whole definition should be enclosed in parentheses, eg
  ```
  IF((CALC=&1TK*2)>52)
  ```
- ***setpoint*** is a constant (e.g. **2.77**) or channel variable specifier (e.g. **13CV**)

Note The equality (**==**) and inequality (**!=**) tests should normally only be used where the quantities being compared are integers. Floating point values are subject to rounding errors. For example, after adding 0.1 to a CV ten times, the result will not necessarily be exactly 1.0

In addition, a **time specifier** may be appended to the above. If a time specifier is present, the alarm will only be set true after the condition has been continuously true for the specified time.

A time specifier has one of the following forms:

Time Specifier	Condition must be continuously true for
/*n*S	*n* seconds
/*n*M	*n* minutes
/*n*H	*n* hours
/*n*D	*n* days

Some sample alarm conditions are shown below:

Condition	Alarm is true if
(2R(II)>51.5)	channel 2R value is greater than or equal to 51.5 ohms
(3+V(AV)<-200)	channel 3+V (averaged over schedule interval) is less than -200mV
((CALC=(&1TK+&2TK)/2)<50)	average of two thermocouple readings is < 50°C
(4ST==1)	today is Monday
(REFT<>-10,45)	temperature inside *DT80* is outside the range -10°C - +45°C
(T><9:00,17:30)	time is between 9am and 5:30pm
(32SV>10000)	10000 or more data records have been logged for schedule A
(1CV<2CV/2M)	1CV is less than 2CV, and has been for at least 2 minutes
(4DS==0)	digital input 4DS is low
(1CV(ND)>1)	1CV is greater than or equal to 1. Don't display this alarm.

Note that by default the value of the channel that is tested in an alarm condition is neither logged nor returned. It will, however, be displayed, unless you disable this using the **ND** or **W** options.

If you want to log or output the channel's value each time it is tested then include the **LM** (log measurement) option, e.g.

```
ALARM(1TK(LM)>35)"Hot"
```

Complex Conditions

As indicated above, only relatively simple condition tests can be included in an alarm command. There are two ways to perform a more complex test.

Boolean Expressions

An arbitrarily complicated **boolean expression** can be constructed and assigned to a CV, which can in turn then be tested in an alarm command. For example:

```
RA5S
 1V 2V 3V 3CV
 9CV=((&1V>2.2)AND(&1V/&2V<=0.9)AND(&3V>=(&1V+&2V)))OR(3CV=0.0)
 ALARM(9CV>0.5)"Condition red"
```

Note that the syntax for boolean expressions is quite different to that used in alarm conditions.

In the above example 9CV will get the value 1.0 if the expression evaluates to true, otherwise 0.0

You can also use the result of a boolean expression in an **arithmetic expression**, making use of the fact that the value of the boolean expression is always 1.0 or 0.0. For example,

```
12CV=4CV*(1CV>2.5)+5CV*(1CV<2.5)
```

will set 12CV to the value of 4CV if 1CV is greater than 2.5, otherwise it will set it to the value of 5CV.

See *Expressions* *(P66)* for more information about using expressions.

Combining Alarms

An alternative method of building up a complex alarm condition is to chain a number of consecutive alarm commands together. They are combined using logical operators (**AND**, **OR** or **XOR**), which replace the *digitalAction*, *actionText* and *actionProcesses* of all except the last alarm. The actions associated with the combined test are attached to the last alarm. Any alarm delay period is also associated with the last alarm.

For example, the combined alarm

```
ALARM(1*TK>100)OR
ALARM(1+TK>100)OR
ALARM(1-TK>100)AND
ALARM3(T>10:00:00)"Temp Error"{1DBO=12}
```

produces a single alarm output based on several temperature tests and a time test. The combined alarm becomes true when any one of **1*TK**, **1+TK** or **1-TK** exceeds 100°C after 10:00:00 am. Notice that the alarm conditions are evaluated sequentially ("left to right"); the three logical operators (**AND**, **OR** or **XOR**) all have equal precedence.

Note also that the type of alarm (single shot vs. repeating) and the alarm number are solely determined by the last channel in a chain of concatenated alarm channels e.g.

```
ALARM27(1CV>1)AND
ALARM5(2CV>4)"boo"
```

is exactly equivalent to

```
IF99(1CV>1)AND
ALARM5(2CV>4)"boo"
```

ie it's a single shot alarm with ID 5.

Alarm Digital Action Channels

One or two comma-separated **digital action channels** can be declared for each alarm. These channels will then mimic the state of the alarm. That is, these outputs are set to their default state if the alarm tests false, and are set to there non default state if the alarm tests true:

Digital action channels can be:

- digital outputs (*n*DSO)
- **Attn** LED output (1WARN)
- latching relay output (1RELAY)
- channel variables (*n*CV)

These will be set according to the following table:

Digital Action Channel	Value if Alarm FALSE	Value if Alarm TRUE
1..4DSO *(DT80/82I/85)* 1..3DSO *(DT81/82E)*	1 (high/off)	0 (low/on)
5..8DSO *(DT80/85)* 4DSO *(DT81/82E)*	0 (low)	1 (high)
1WARN	0 (LED off)	1 (LED on)
1RELAY	0 (relay open)	1 (relay closed)
*n*CV	0.0	1.0

Typically, the digital state outputs are used to annunciate the *DT80* alarm by switching devices such as relays, sirens and lights, or to directly control actuators and similar equipment.

For example,

```
RA1M ALARM(4TK<-1)3DSO"Heater on^M"
```

will check the temperature every minute. If it drops below -1°C a message will be output and digital output **3D** will go low, energising an external heater relay. The digital output will remain low (heater on) until the temperature (measured every minute) is no longer below -1°C.

Similarly,

```
RB10S ALARM(2+TC>2100)2CV,1RELAY"ReactorScram"
```

checks a temperature every 10s; if it exceeds 2100°C then the relay will close and 2CV will be set to 1.0 until the temperature drops back below the setpoint. Once this occurs the relay will open and 2CV will be set back to 0.0.

Alarm Action Text

Action text may be included in an alarm command. This text string is automatically returned to the host computer and/or logged to the internal file system:

- once whenever the state of a single-shot alarm (ALARM) goes from false to true, or
- repeatedly at the controlling schedule's rate while a repeating alarm (IF or DO) remains true.

Up to 245 characters of action text can be included in each alarm.

Note The action text may be truncated when it is logged. A fixed amount of space is allocated in the log file for storing the alarm text, which is set by the ALARMS:W*n* (alarm width) schedule option; see *Schedule Options* (P45). If the default setting of 60 is used, each logged alarm string will be truncated to 60 characters.

Setting the alarm message switch (P203) to /z stops the return of the action text to the host – in a similar way to the NR (no return) channel option.

Destination for Text

Action text is normally enclosed in "double quotes", in which case it is returned to the host computer using the currently active communication port.

If, however, the action text is instead enclosed in 'single quotes', the *actionText* is sent exclusively to the RS232 Host Port on the logger. This is useful for communicating with modems when they are in command mode and when the host port is used for other purposes.

Substitution Characters

Special substitution characters can be placed into *actionText*. These instruct the *DT80* to dynamically insert the following information when the alarm returns and/or logs its action text:

Alarm text	where	Substitutes the following	Example
!		DT80 serial number, **:**, alarm number	080035:8
!!		! character	!
@		time at which action text was returned (in P39 and P40 format)	12:13:14.634
@@		@ character	@
#		date at which action text was returned (in P31 format)	17/9/2007
##		# character	#
?C		standard channel name	2PT385
?N		user channel name	Boiler
?R		relation (test condition)	>100
?U		channel units	degC
?V		channel value when alarm tested true (use **FF***n* etc. channel options to control format)	100.2
?*A*	*A* = any letter (A-Z) other than **CNRUV**	**not valid**	
?*n***F***p*	*n* = 1-1000, *p* = 0-7	value of *n*CV in fixed point format, *p* decimal places	-1257.42 (*p*=2)
?*n***E***p*	*n* = 1-1000, *p* = 0-7	value of *n*CV in exponential format, *p* decimal places	-1.26E3 (*p*=2)
?*n***M***p*	*n* = 1-1000, *p* = 0-7	value of *n*CV in mixed format, *p* significant digits	-1.3E3 (*p*=2)
?*n***F**	*n* = 1-1000	same as **?***n***F1**	-1257.4
?*n***E**	*n* = 1-1000	same as **?***n***E1**	-1.3E3
?*n***M**	*n* = 1-1000	same as **?***n***M1**	-1E3
?*n**A*	*A* = any letter (A-Z) other than **FEM**	**not valid**	
?*n***$**	*n* = 1-50	value of string variable *n*$	east
?*n*	*n* = 1-1000	same as **?***n***F1**	-1257.4
??		? character	?
?		same as **?V**	100.2
c	*c* = any character	*c*	a

Note Substitution characters are not case sensitive (**?v** is equivalent to **?V**)

Special Characters

Special characters may be inserted in alarm strings using control character (e.g. **^M**) or backslash (e.g. **\013**) notation. See *ASCII-Decimal Tables* *(P316)* for more information.

For example,

```
ALARM(3TT>120)"\192 hautes temp\233ratures!! ?v \176C^M^J"
```

will return/log the following string when the specified temperature is exceeded:

```
À hautes températures! 129.4 °C
```

In this example the **\192** and **\233** insert the accented characters, **\176** inserts the degree symbol, and **^M^J** adds a carriage return/line feed pair. Note also the **!!** to generate a single exclamation mark, and the **?v** substitution string, which is replaced by the channel value.

If the software used to enter the program text supports it, you could alternatively have entered the special characters directly, i.e.

```
ALARM(3TT>120)"À hautes températures!! ?v °C^M^J"
```

Be aware that many extended ASCII character codes display differently on the *DT80*'s LCD compared with the host computer. See *ASCII-Decimal* Tables *(P316)*.

Examples

Text Labels

The **DO** command in conjunction with alarm text provides a simple way to output a text string in a schedule, e.g.:

```
RA5M DO"Boiler 1^M^J" 1TK 2TK DO"Boiler 2^M^J" 3TK 4TK DO"^M^J"
```

will include a heading before each group of measurements:

```
Boiler 1
1TK 239.4 degC
2TK 99.9 degC
Boiler 2
```

```
3TK 212.4 degC
4TK 90.9 degC
```

Modem Commands

The schedule command

```
RC2+E DELAY=500 DO"AT&F E0 Q1 S0=2 ^M"
```

instructs the *DT80* to output a modem initialization string 500ms after an external event occurs (**2+E**); for example, when the modem powers up.

Alarm Action Processes

Action processes can be any *DT80* functions to be executed when an alarm is true. These functions can be reading input channels, setting output channels, calculations, setting parameters and switches, and so on.

In addition, action processes are a very powerful programming facility for the *DT80*. Use them to perform a wide range of program-related functions such as re-programming on events, adaptive schedules (see examples below), programmed calibration cycles, management of digital state outputs, and management of the Serial Channel.

Action processes are also useful with unconditional alarm commands (**DO** commands) as a means of executing a *DT80* command (as opposed to a channel) within a schedule. See *Executing Commands in Schedules* *(P54)* for more details.

Action processes are placed within braces **{ }** as the last element in an alarm command. Each "process" is either:

- a channel definition (e.g. **1+V(=1CV)** or **3DSO=0**), or
- a command (e.g. **XC** or **P12=5** or **SATTN** or **LOGONA**), or
- a schedule trigger re-definition (e.g. **RA100T**)

Alarm commands cannot be included.

Any number of processes may be included, but they must all be on the same line. Processes can be separated by semi-colon (**;**) or space characters.

Order of Execution

When an alarm is triggered, things happen in the following sequence:

1. Digital action channels (if any) are set to the required value
2. Alarm text (if any) is generated and returned/logged
3. Any channels in the action process list are evaluated, left to right. All channels in an alarm process list are treated as working channels – they are neither returned, logged nor displayed.
4. Any commands or schedule trigger re-definitions are queued for execution, working left to right.
5. Any further channels or alarm commands in the current schedule are executed
6. Any queued commands, including the ones generated by the alarm, are executed.

For example, the job

```
BEGIN
RA5S ALARM1(3TK>30){XB 1DSO=0 SATTN} 4V(NR)
RC1S 1V
RBX 1SERIAL("{boo!}")
LOGON
END
```

will perform as follows:

1. Schedules A & C will become due at the same time, because A's scan rate is an exact multiple of C's. A will run first, because, as noted in *Triggering and Schedule Order* *(P53)*, A comes before C in the priority order.
2. Channel **3TK** exceeds 30 so the alarm is triggered. The alarm is numbered and logging is enabled so an alarm record will be logged, although the alarm text field will be an empty string.
3. Channel **1DSO** is evaluated – output **1D** is set low.
4. The command string **XB;SATTN;** is queued for execution.
5. Channel **4V** is evaluated. It's value is logged and displayed but not returned.
6. Schedule A is now finished; schedule C is selected to run next. It does not actually run, however, because there are queued commands to execute.
7. The **XB** command is now executed. This causes the B schedule to become due.
8. The **SATTN** command is executed, which turns on the **Attn** LED
9. There are no more queued commands so the C schedule can now run. Channel **1V** is evaluated and logged/displayed/returned.

10. Schedule B is also due, so it now runs. The **1SERIAL** channel is evaluated, which causes a string to be sent out the serial sensor port.
11. There is nothing further to do so the logger idles until schedule C next becomes due.

In most applications the ordering is not particularly important as all of the alarm actions occur within a very short space of time. However, it can cause surprises in some circumstances, as illustrated below.

Trap – Commands Don't Affect Channels in Same Schedule

Any commands executed in an action process list will not take effect until after all channels have been processed. For example, if you wanted some measurements to be returned in fixed format mode and some in free format, you might try:

```
RA1S DO{/H/R} 1V  DO{/h/R} 2V     ' does not work!
```

but in fact both channels will be returned in free format mode.

To achieve the desired result you need to do something like:

```
RA1S 1V DO{/H/R XB}
RBX 2V DO{/h/R}
```

In this example **1V** will be returned in free format mode, then we switch to fixed format mode, then we issue the command to poll schedule B. Schedule B will then do the same thing: return **2V** in fixed format mode, then switch back to free format mode so that the next time schedule A runs it will return its value in the correct format.

Note In the *DT80*, commands have higher priority than schedules. If there are any queued commands outstanding, they will be executed ahead of any schedules that happen to be due. However, once a schedule starts executing, it always runs to completion – any queued commands will be held off until the schedule completes.

Trap – Don't Use DELAY Between Commands

The **DELAY=***ms* function is a channel, not a command. It therefore cannot be used to insert a delay between two commands. For example, if you wanted to light the **Attn** LED for 5 seconds to indicate that a measurement was about to be taken, you might try

```
RA20M DO{SATTN; DELAY=5000; CATTN; XB} RBX 1V   ' does not work!
```

but this is no good because the **DELAY**, being a channel, is executed first, then **SATTN;CATTN;XB** in quick succession.

The **PAUSE** *ms* command does the same thing as **DELAY** except that it is a command, so you can use:

```
RA20M DO{SATTN; PAUSE 5000; CATTN; XB} RBX 1V  ' OK
```

(The semicolons between commands are optional in most cases. They are included in the above example because they make the program a little more readable, especially when commands with space-separated parameters are used.)

Note also that a simpler way to implement the above functionality would be to not use commands at all, e.g.:

```
RA20M 1WARN=1 DELAY=5000 1WARN=0 1V
```

or, even better:

```
RA20M 1WARN(5000,R)=1 1V
```

Examples

Controlling a System

Alarm action processes can be used to control a system or process. This is often preferable to the method used in the example in *Alarm Digital Action Channels* *(P79)* because it allows some hysteresis to be included.

For example,

```
RA1S
  ALARM(1TK<74.75)"Heater ON"{1DSO(W)=0}
  ALARM(1TK>75.25)"Heater OFF"{1DSO(W)=1}
```

is a simple heater control for a water bath. The two alarms work to hold the temperature at 75°C ± 0.25°C.

Adaptive Scheduling

Adaptive scheduling is the dynamic adjustment of the acquisition of data about a system or process as the system or process changes.

As the examples below show, adaptive scheduling can reduce total data volume while giving greater time resolution when required.

The schedule:

```
RA15M
  1V("Wind speed",S1)
  ALARM(&1V>5.25){RA2M}
  ALARM(&1V<4.75){RA15M}
```

measures wind speed

- every 2 minutes if wind speed is greater than 5m/s, or
- every 15 minutes if wind speed is less that 5m/s

Note the deliberate 0.5m/s hysteresis to prevent oscillation around the switchover point. If the measured wind speed exceeds 5.25m/s, schedule A's trigger is re-defined to run every 2 minutes. When it drops below 4.75m/s it is reset back to

every 15 minutes.

The following job:

```
RC30M 1TK("Oven Temp")
RD1M  ALARM(5TK>120){GC}  ALARM(5TK<110){HC}
LOGONC HC
```

continuously monitors the temperature of an oven and logs the temperature whenever it exceeds 120°C.

Initially the logging schedule (C) is halted (**HC**). Schedule D checks the temperature every minute, and when it exceeds 120°C schedule C is started (**GC**), and it is stopped again once it goes below 110°C.

Using an Alarm to Poll a Schedule

As mentioned above, if any channels are included in an action process list then they cannot be logged, returned or displayed. This limits the types of channels that can usefully be included in an action process list to:

- output channels (e.g. **2DSO=0**)
- calculations (e.g. **1CV=1CV+1**)
- channels that assign to a CV (e.g. **2*V(=2CV)**)

If you need to conditionally take measurements and log/return them, you will need to set up a separate schedule and then use the alarm to poll it.

For example, the job:

```
BEGIN
1..3CV(W)=0
RA1S
 1CV(W)=1CV+1
 ALARM(1CV>3CV){XB 2CV(W)=2CV+1 3CV(W)=2^3CV}
RBX LOGONB
 1..5TK
END
```

logs data at increasing intervals as the experiment proceeds. The program calculates the next log point as an incrementing power of 2 seconds — that is, it logs the temperatures at t = 0, 1, 2, 4, 8, 16,… seconds. The following table lists the values of the three CVs at the point at which the **ALARM** statement is executed.

Time (s)	1CV	2CV	3CV	
0	1	0	0	Alarm active – B schedule polled
1	2	1	2	Alarm active – B schedule polled
2	3	2	4	
3	4	2	4	Alarm active – B schedule polled
4	5	3	8	
5	6	3	8	
6	7	3	8	
7	8	3	8	Alarm active – B schedule polled
8	9	4	16	
				etc.

(Remember that **(1CV>3CV)** means 1CV is greater than or equal to 3CV.)

The following example will log all voltage readings that exceed 200mV:

```
BEGIN
RA1S IF(2V(=1CV)>200){X}
RX 1CV("Vout~mV")
LOGONX
END
```

Note that assigning to a CV in this way and then reporting the CV value is preferable to including **2V** in both schedules. Alternatively, a reference (**&2V**) could have been used.

Executing Commands in Schedules

The following will output a directory listing every time a positive edge is received on digital input 7:

```
RA7+E DO{DIR"B:"}
```

Selecting a Job to Run

The following schedule

```
RA1SERIAL""
```

```
1SERIAL("%1d",=1CV)
IF(1CV><0.5,1.5){RUNJOB"MIX"}
IF(1CV><1.5,2.5){RUNJOB"CHURN"}
IF(1CV><2.5,3.5){RUNJOB"GRIND"}
```

will run when a character is received on the serial sensor port. If the character is **1**, **2** or **3** then the indicated job will be loaded and run, replacing the current job.

Automatic Data Archive

The schedule command

```
RE1D DO{MOVEDATA"Job1"A}
```

instructs the *DT80* to — every midnight (**1D** trigger) — move all logged data for schedule A of Job1 to an archive file on the USB memory device.

Alarm Records

Real Time Alarm Return

If an alarm is triggered while free format mode (**/h**) is selected, the configured alarm action text (if any) will be returned.

If an alarm is triggered while fixed format mode (**/H**) is selected, a fixed format **alarm record** will be returned. This has a similar format to a fixed format data record (see *Format of Returned Data* *(P25)*)

For example, the job:

```
BEGIN"B1" RB1S ALARM8(1V(S1)>1.5)"OverPressure ?vMPa^M^J" END
```

would, when triggered, return text similar to the following if normal (**/h**) mode was selected:

```
OverPressure 1.563MPa
```

In fixed format (**/H**) mode, however, it would return an alarm record:

```
A,080035,"B1",2006/04/16,14:32:01,0.254870,0;B,8,1,"OverPressure 1.563MPa^M^J";0078;3D95
```

An alarm record consists of:

- the usual fixed format header and trailer (serial number, job name, timestamp, error check fields)
- a `0` to indicate real time (as opposed to logged) data
- the schedule (`B`)
- the alarm number (`8`)
- the transition type (`1` – false to true)
- the alarm text string (if any). Note that control characters (ASCII code < 32) are not output; they are left in the string in **^***x* notation.

The real time return of alarm action text or alarm records can be disabled using the **/z** switch.

Logging Alarms

Alarm records may also be **logged** to the *DT80*'s internal file system. This will occur if an alarm number is provided (e.g. **ALARM7**), and logging is enabled for the enclosing schedule.

As with data, when logged alarm records are **unloaded**, they will be returned as fixed format records, as illustrated above.

By default, an alarm record is only logged when an alarm is triggered, i.e. its state changes from false to true. However, by setting parameter **P9=3**, the *DT80* will also log a record when the alarm goes inactive (true to false).

Also note that numbered **IF** and **DO** commands (which are seldom used) will log an alarm record every time their schedule executes, while their condition is true.

The following table summarises what is logged, and what is returned for the various types of alarm command.

Alarm Command	State/Transition	Parameter 9 (default P9=1)	Logged Transition Type, Alarm Text	Returned AlarmText
ALARM(*test*)"*actionText*"	False to true ↑	x	—	*actionText*
	Continuing true	x	—	—
	True to false ↓	x	—	—
ALARM*n* (*test*)"*actionText*"	False to true ↑	P9=1 or 3	1,"*actionText*"	*actionText*
		P9=0 or 2	—	*actionText*
	Continuing true	x	—	—
	True to false ↓	P9=0 or 1	—	—
		P9=2 or 3	3,"ALARM*n* FALSE"	—
IF(*test*)"*actionText*" (or **ALARMR**)	False to true ↑	x	—	*actionText*
	Continuing true	x	—	*actionText*
	True to false ↓	x	—	—
IF*n*(*test*)"*actionText*" (or **ALARMR**)	False to true ↑	P9=1 or 3	1,"*actionText*"	*actionText*
		P9=0 or 2	—	*actionText*
	Continuing true	x	2,"*actionText*"	*actionText*
	True to false ↓	P9=0 or 1	—	—
		P9=2 or 3	3,"ALARM*n* FALSE"	—
DO"*actionText*"	x	x	—	*actionText*
DO*n*"*actionText*"	x	x	2,"*actionText*"	*actionText*

Polling Alarm Inputs

The current values of the channels being tested in alarm conditions can be polled (requested) by the host computer at any time. There are three commands for polling alarm data:

Command	Function
?*n*	returns the current input value of alarm *n* (if *n* = 0 then all un-numbered alarms are returned)
?*x*	returns the current input values of all alarms in schedule *x*, where *x* = **A**, **B**,…**K**, **X**
?ALL	returns the current input values of all alarms in all schedules

The output of each of these commands consists of:

- the alarm number (A*n*). When un-numbered alarms are polled, the alarm number is returned as A0
- the schedule to which the alarm belongs
- the alarm condition (so that un-numbered alarms can be distinguished). For an alarm with no condition (i.e. DO), the word DO is shown
- the current value of the channel being tested in the alarm condition

For example

```
BEGIN
RA2S
 ALARM4(2R>50)"High R"
 ALARM(1CV<>-10,10){2CV=2CV+1}
 IF(2CV>4){1V(=9CV)}
 ALARM5(9CV<100){RA100T}
END

?ALL
A4 A 4R>50 1300.6
A0 A 1CV<>-10,10 99.0
A0 A 2CV>4 102.0
A5 A 9CV<100 0.0
```

If the *DT80* is set to formatted mode (**/H**) then formatted mode records containing the same information are returned.

The web interface (Series 2 only) will also indicate the status and value of alarm channels.

Part G – Logging and Retrieving Data

Logging Data

By default, the *DT80* returns measurement data to a host computer in real time. However, the *DT80* can also automatically record each reading taken for some or all of a schedule's channels. These data are stored in the *DT80*'s internal memory, and can be retrieved at a later date, using a USB memory device or via one of the communications ports, or via the web interface (Series 2 only).

Each reading is automatically timestamped.

Logged data is retained in the internal memory until it is explicitly cleared, even if the *DT80* is reset or loses power.

Enabling and Disabling Data Logging

LOGON and LOGOFF Commands

By default, data logging is disabled when a schedule is entered. The following commands switch logging on or off. They may be entered as part of a job, or they may be sent at any time after a job has started running:

Command	Function
LOGON	Enables logging (data and alarms) for all schedules.
LOGOFF	Disables logging (data and alarms) for all schedules.
LOGON*sched*	Enables logging for schedule *sched* (data and alarms)
LOGOFF*sched*	Disables logging for schedule *sched* (data and alarms)

For example the following job defines a schedule and enables logging:

```
BEGIN"LUMPY" RA2M 2V 3V LOGONA END
```

This will create a store file with the default size. Every two minutes, two voltages will be measured and the results will be stored, along with the time at which the measurements were taken.

Disabling Data Logging for Specific Channels

If logging is enabled for a schedule then by default all channels defined therein will be logged. To disable logging for specific channels:

- use the **NL** (no log) channel option, or
- use the **W** channel option (working channel; do not log, return or display)

How Data and Alarms are Stored

The DT80 File System

The *DT80*'s internal flash memory is organised as a DOS-compatible file system, which uses files and folders in a similar way to a desktop computer. When a USB memory device is inserted it is treated in a similar way. Note that:

- the USB memory device, if present, is referred to as drive **A:**
- the *DT80*'s internal file system is referred to as drive **B:**
- the *DT80*'s internal RAM disk (a small but higher speed file system) is referred to as drive **D:**

(The **DIR** and **DIRTREE** commands can be used to explore the contents of either drive. For example **DIRTREE B:** will list the names of all files and directories on the internal file system.)

The standard internal file system has a capacity of 128Mbyte. The *DT80* stores approximately 90,000 data values per megabyte of memory, so the internal memory can hold approximately 10,000,000 data values.

The internal RAM disk has a capacity of 128kbyte (approx. 10,000 data values).

Note the RAM disk (**D:**) may be cleared if all power to the *DT80* is lost (including the lithium memory backup battery). It should not normally be used for long term data storage.

Store Files

When a job is first entered, a directory (folder) is created on the internal file system: **B:\JOBS***jobname*. This directory

contains files which record the job's program text and other details about the job.

For each of the job's schedules that contain loggable channels (that is, channels which do not specify the **NL** or **W** options), a data storage sub-directory for that schedule is then created: **B:\JOBS***jobname****sched**.

Finally, a **store file** is created in the schedules data storage directory. Note the following important points:

- A store file is a **pre-allocated, fixed size** file. The size of the file (as returned by the **DIR** command, for example) does not change are data is stored.
- A store file contains two fixed size sections – one for **data** (measured channel values), one for **alarms** (text strings which are logged when a particular condition is true). The sizes of these sections is configurable on a per-schedule basis.
- A store file is a **binary** file. The data contained in it are not directly human-readable. See *Retrieving Logged Data* *(P90)*.
- A store file has a name of the form **DATA_***sched***.DBD**.

For example, the job:

```
BEGIN"BUMPY"
 RA2M 2V 3V
 RB1S 2DS
 RK20S 1V(W)
 LOGONA LOGONK
END
```

would create the following store files:

```
B:\JOBS\BUMPY\A\DATA_A.DBD
B:\JOBS\BUMPY\B\DATA_B.DBD
```

Note that no file is created for schedule K because all of its channels are specified as "working", or "non-loggable" channels. Note also that a file is created for schedule B, even though it initially has logging disabled. This ensures that storage will be available if logging is enabled (using the **LOGONB** command) at some later time.

In the above example, the store files would all have the same, default size (approx. 1Mbyte).

How Much Data Can I Store?

Each time a schedule executes (assuming logging is enabled for the schedule), it writes one **data record** to its store file. A data record consists of the values of all channels defined in the schedule, other than those for which logging has been disabled (using the **NL** or **W** channel options).

As a rule of thumb, one data record uses **10 + (10 x numberOfLoggedChannels)** bytes, assuming "normal" channel types (time/date channels and $ strings require more space)

So for the schedule:

```
RA1S 1V 2CV(NL) 3TK
```

each data record will use 30 bytes, so the default 1Mbyte allocation for data is enough for 1,048,576 / 30 = 34,952 data records. The store file will therefore contain the most recent 9 hours or so of readings, assuming a 1 second scan rate.

How Many Alarms Can I Store?

Normally, one alarm record is logged each time a numbered alarm is triggered, i.e. its state goes from false to true. However, as discussed in *Logging Alarms* *(P84)*, the true-to-false transition may optionally also be logged, and numbered **IF** and **DO** alarm commands may log a record each time their schedule executes while their condition is true.

As a rule of thumb, one alarm record uses **12 + alarmWidth** bytes, where **alarmWidth** is set using the **ALARMS:W***n* schedule option; see *Schedule Options* *(P45)*. So assuming the default setting of **60** is used, each alarm record will use 72 bytes. The default 100kbyte allocation will therefore store 102,400 / 72 = 1,422 alarm records.

How Fast Can I Log Data?

The time taken to log one data record for a schedule is essentially the sum of:

- measurement time – the time taken to acquire data for all channels in the schedule. For digital channels and channel variables (CVs) this is close to negligible; for analog measurements it can be significant (normally at least 30ms per measurement); for serial channels it can be very significant (possibly many seconds for SDI-12, for example)
- processing time – the time taken to perform any linearisation or other data manipulation calculations that may be required
- communications time – the time taken to format and return real time data values over a communications link
- logging preparation time – the time taken to generate a data record to be logged
- file system time – the time taken to physically write the data to the internal flash disk or external USB device.

The first three of these depend on the job and the logger settings. We can largely eliminate them by defining a job consisting only of CVs, and switching off real time data returns (**/r**).

As discussed above, there is a storage overhead associated with each data record; hence 20 records each with one channel will require more space than one record with 20 channels. The same goes for time – there is a fixed time overhead in preparing a data record, plus a variable time which depends on the number of channels.

The following table list some typical logging rates:

Schedule	Description	Logging rate
`/r RA("B:") 1CV`	log one CV to internal memory	55 records/s
`/r RA("B:") 1..20CV`	log 20 CVs to internal memory	40 records/s
`/r RA("A:") 1CV`	log one CV to 512M USB device	4 records/s
`/r RA("A:") 1..20CV`	log 20 CVs to 512M USB device	3 records/s
`/r RA("D:",DATA:100KB) 1CV`	log one CV to internal RAM disk	120 records/s

There may be some variation in performance depending on the brand and capacity of the USB device, but in general logging to USB will be around an order of magnitude slower than logging to the internal flash memory.

Logging Options

Various data logging parameters can be changed by means of **schedule options**. These options are inserted in a schedule definition just before the schedule trigger. See *Schedule Options* (P45) for details.

Schedule options can be used to specify:

- the logging destination. Using the **"A:"** schedule option it is possible to configure a schedule to data directly to a USB memory device. In this case the store file will be placed in the **A:\SN***serial-num***\JOBS***jobname***\sched*** sub-directory.
- the space allocated for data. This can be specified in bytes, records, or (for time-based schedules) as a time period ("I want to store 30 days of data")
- the space allocated for alarms
- whether new data/alarm records are permitted to overwrite old records (**OV**) or whether logging should stop when the store file is full (**NOV**).

For example, the following schedule definition:

```
RA(DATA:30D)1M 1V 2V LOGONA
```

will allocate a store file with space for 43,200 data records (30x24x60). No space is allocated for alarms because no alarms are defined in this schedule.

Note When determining how much space to allocate for data storage, it is important to ensure that adequate free space remains on the 128MB internal flash memory. If you choose to retrieve logged data by either:

- unloading it to an FTP server, or
- unloading in DBD format via the web interface (dEX)

then there must be sufficient space available on the internal drive to create a temporary file prior to sending to the server. The space required will depend on the amount of data being unloaded. If you unload the entire contents of a 10MB storefile to FTP in DBD format then you will need 10MB of free space for the temporary file. If you unload in CSV format then the space required will be of the order of 10MB, but may be less or more depending on the data values.

As a rule of thumb, if you plan to use one of the above unload methods then you should generally size your storefiles so that they occupy no more than 50% of the total space on the *DT80* internal drive.

Note It is normally better to always log data to the internal file system. Logging directly to a USB device is possible, but is subject to the following caveats:

- The logging performance is significantly slower than for the internal drive.
- There is the potential for data corruption if the USB device is removed during a write operation. Be sure to always halt logging and use the **REMOVEMEDIA** command (see *Using a USB Memory Device* (P106)) to shut down the device prior to removing it.
- The *DT80*'s USB socket is designed for easy access, and will not necessarily retain a USB device securely over a long period, particularly if the *DT80* is wall mounted or subject to vibration.

Factors Which May Prevent Logging

When a job is loaded onto the *DT80*, the logger will attempt to create all required store files. If this is not possible then the job will not be loaded.

Insufficient Space to Create Store File

When a job is entered, the *DT80* attempts to create a store file of the required size. If, however, there is insufficient free space on the selected logging drive (or it is not present at all) then an error will be reported and the job will not be loaded.

To determine how much space is available on the internal file system for creating new store files, see *Checking Logging Status* (P89).

Because the store files are fixed size, a lack of free disk space will normally not be a problem once the job has been started successfully.

If, however, the job is configured to log direct to a USB device, and the device is removed during operation, then a "**Cannot log**" error message will be displayed on the LCD and the **Attn** LED will start flashing. The schedule will still execute – channels will be measured and values returned – but no data will be logged.

If the USB device is replaced with a new one during operation then the *DT80* will attempt to create store files on the new device. If this fails (e.g. there is insufficient free space) then again the job will keep running, with the **Attn** LED flashing. Once you insert a USB device on which the store files can be created, then the **Attn** LED will stop flashing.

Store File Full

Normally, when a store file fills up it will automatically begin overwriting the oldest logged data. However, in some circumstances the older data may be more valuable than the newest. In these cases you would use the **NOV** (no overwrite) schedule option. If this option is set then logging for that schedule will stop when the store file becomes full, and the **Attn** LED will start flashing.

Logging will resume (and the **Attn** LED will stop flashing) if you delete the logged data from the storefile using the **DELD** command.

To determine how many records have been logged to a store file, see *Checking Logging Status* *(P89).*

Pre-existing Store Files

When a job is entered, the *DT80* checks whether there are any pre-existing store files associated with the job name. For example, if you enter a job called "FIDO" (using **BEGIN"FIDO"** ...) then the *DT80* will check to see if there are any existing store files under the **B:\JOBS\FIDO** directory.

If there are existing store files, the *DT80* then checks to see whether the existing store files were created by the same job as the one being entered (this information is encoded within the store file). Note that to be considered the same, the new job's program text must be identical to that used to create the store files.

If the new job matches then logging will commence and data will be added to the existing store files.

If, however, the job being entered is not the same as the job used to create the store files then the new job will not be loaded and an error message will be displayed, e.g.:

```
Cannot log: job 'FIDO' has existing data/alarms
```

To get around this you need to either:

- rename the new job, or
- remove the existing data in the store files, using **DELD**.

This check ensures that all data in a store file is consistent.

Checking Logging Status

A number of commands can be used while a job is running to monitor the data logging status. You can also determine all these details via the web interface.

Free Space for Creating New Store Files

To determine how much space is available on the internal file system for creating store files you can use the **DIR B:** command (or **DIR A:** for a USB device). This will list the various files stored in the root directory, and will then show the remaining free space, e.g.:

```
3 File(s)    42902196 Bytes free
```

Alternatively, system variable 1SV *(P35)* will return the current free space, in kbytes (1kbyte = 1024 bytes), on the internal file system (or 3SV for a USB device), e.g.:

```
1SV
1SV 41896.0
```

Number of Records Logged

To determine how many records have been logged to a store file, and the associated date/time range, you can use the **LISTD** command. See *LISTD – List Available Data* *(P90)*.

The number of logged data and alarm records for each schedule of the current job are also available in system variables 30SV – 53SV (see *System Variables* *(P35)*), e.g.

```
32SV
28.0
```

Retrieving Logged Data

Overview

There are several different ways to retrieve logged data from the *DT80*.

- Use the **Retrieve Data** function in *dEX*. The graphical web-based interface allows you to select the desired time range, among other options. Data will be downloaded to your computer and saved as a CSV or DBD format file.
- Interactively send a data unload command (**COPYD**) to the logger's command interface, which will output logged data in CSV, fixed or free format to the active communications port.
- Insert a USB memory device and use **COPYD** to unload data to file(s) on the USB device in the desired format (CSV/DBD/fixed/free). To automate this process the command can be placed in an ONINSERT file on the USB device, so that the unload is performed as soon as the USB device is inserted.
- Include a **COPYD** command in your job to periodically unload data to a remote FTP server, or to a file on the internal file system or USB device.
- Use **COPYD** (manually, or from the job – possibly in response to some event) to unload data to a local **archive file**. An archive file is a DBD file which contains a read-only snapshot of the main store file, with any empty space removed. Archive files can then be unloaded at a later date (using **COPYD**) into a CSV format file.
- Use an FTP client to access the *DT80*'s FTP server and collect any archive files or locally stored CSV files.

Unload Commands

The *DT80* provides three related commands for unloading and managing logged data:

- **LISTD** gives details of the data available to unload, such as the number of logged records and the time range that they cover.
- **COPYD** is used to extract selected data from store files and save it in the selected format to the selected destination.
- **DELD** is used to remove data from a store file.

These three commands share a similar syntax: the command is followed by zero or more space-separated **options**. Each option has the form *name*=*value*. The *value* may optionally be enclosed in quotes, i.e. *name*="*option value*". A typical command line might be:

```
COPYD start=new dest=a:
```

Option names and values are not case-sensitive, and the options may be specified in any order.

Option names (not values) may also be abbreviated, so long as the result is not ambiguous. Thus the following is equivalent to the previous command line:

```
copyd DEST=A: ST=NEW
```

All options have a default value, which will be used if the option is not specified.

LISTD – List Available Data

Using LISTD

In its simplest form, the **LISTD** command will list details for all store files associated with the current job. For example:

```
LISTD
 Job      Sch Type       Ov Lg Go  Recs      Capacity
 ======== === ========== == == ==  ========  ========
*SAMPLE   A   Data  Live Y  Y  N         46     34952
*SAMPLE   A   Data  Arc                 38        38
*SAMPLE   B   Data  Live Y  Y  N         23     52428  —
*SAMPLE   B   Alarm Live Y  Y  N          3      1455
*SAMPLE   B   Data  Arc                 19        19
*SAMPLE   B   Alarm Arc                  2         2

       First                Last                 File
       ===================  ===================  ========================================
       2010-03-01 09:54:23  2010-03-11 19:32:00  B:\JOBS\SAMPLE\A\DATA_A.DBD
       2010-03-01 09:54:23  2010-03-04 18:50:55  B:\JOBS\SAMPLE\002_20100311T193043.DBD
       2010-03-01 09:54:24  2010-03-11 19:32:00  B:\JOBS\SAMPLE\B\DATA_B.DBD
       2010-03-01 09:54:40  2010-03-11 19:32:00  B:\JOBS\SAMPLE\B\DATA_B.DBD
       2010-03-01 09:54:24  2010-03-04 18:50:55  B:\JOBS\SAMPLE\002_20100311T193043.DBD
       2010-03-01 09:54:40  2010-03-01 09:54:48  B:\JOBS\SAMPLE\002_20100311T193043.DBD
```

(The above listing has been split in order to fit with this manual's page width.)

Each row of the report describes a **store**. A store is a set of logged data or alarm records for a particular schedule. Each store is contained within a **store file** (.DBD file). There can be multiple stores in the one store file.

There are two different types of store file: **live** (`Live`) and **archive** (`Arc`).

Live Store Files

Live store files are the files to which data and alarm records are written, as they are sampled. Each schedule (that has loggable channels) has a live store file called **DATA_*s*.DBD**, which contains one data store and/or one alarm store. In the above example, there are three live stores listed:

- schedule A's data store, which currently contains 46 logged data records out of a capacity of 34952
- schedule B's data store, which currently contains 23 logged data records
- schedule B's alarm store, which currently contains 3 logged alarm records

In this example schedule A does not have any alarms defined, so it does not have an alarm store in its live store file.

For each live store, the following information is listed:

- `Ov` (Overwrite) column: indicates whether old records will be overwritten by new ones. (This is controlled by the **OV** and **NOV** schedule options, see *Schedule Options* *(P45)*.)
- `Lg` (Log) column: indicates whether logging is currently enabled for this schedule. (This is controlled by the **LOGON** and **LOGOFF** commands, see *LOGON and LOGOFF Commands* *(P86)*.)
- `Go` column: indicates whether the schedule is currently running. (This is controlled by the **G** and **H** commands, see *Halting & Resuming Schedules* *(P54)*.)
- `Recs` column: current number of logged records
- `Capacity` column: maximum number of records that can be stored. (This is controlled by the **DATA** and **ALARMS** schedule options, see *Schedule Options* *(P45)*.)
- `First` column: timestamp of the oldest logged record in the store
- `Last` column: timestamp of the newest logged record in the store
- `File` column: name of the store file that contains this store

Archive Files

An archive file contains a "snapshot" of a live store file. Archive files have the same format (.DBD) as live store files, except that all empty space is removed for each store.

Archive files are created by using the **COPYD** command to unload data from a live store file in .DBD format and save it to a file. By default, archive files have an automatically generated file name which indicates the date and time at which they were created.

An "archive file" is therefore really just an unload output file, as is a CSV file. The difference is that because it is still in the logger's native .DBD format, the *DT80* knows exactly what is in it – which schedules, channels, time ranges and so on. Archive files will therefore appear in a **LISTD** report, whereas CSV format files will not. You can also selectively unload data from an archive file the same as you would from a live store file.

In the sample **LISTD** output shown above, one archive file has been created, named **002_20100311T193043.DBD**. The name indicates that it was created on 11-Mar-2010 at 19:30:43. The file name does not indicate anything about the time range covered by the records therein – this information is obtained from the **LISTD** report.

In this case the archive file contains three stores:

- a snapshot of schedule A's data store, which contains 38 data records
- a snapshot of schedule B's data store, which contains 19 data records
- a snapshot of schedule B's alarm store, which contains 2 alarm records

Notice that for an archive file, the number of records in each store is always equal to the capacity.

Also note that the `Ov`, `Lg` and `Go` columns are not applicable for archive files, as you cannot log new data to an archive file.

Orphans

You may occasionally see the word `[orphan]` displayed at the end of a row in a **LISTD** report. This indicates that the job used to generate the data in the file is no longer present on the *DT80*. In other words, the store file has lost the "parent" job that created it – hence the name.

For example:

```
B:\JOBS\WEST3\000_20100312T143919.DBD [orphan]
```

indicates that version of the `WEST3` job that created the data saved in this archive file no longer exists – it may have been modified or deleted.

Orphaned live store files should normally never occur, because the *DT80* will refuse to load a job if logged data exists that was generated by a different job with the same name. Note however that any archive files that may be lying around are not checked, so if you change the contents of an existing job then its archive files will become orphans.

Orphan store files are ignored by **COPYD**, so if you wish to keep the data in them you will need to manually copy the files using the **COPY** command, or retrieve them using an FTP client.

LISTD Options

The **LISTD** command supports a number of options which can be used to filter the results, so the report will only list information for the data and alarm stores that you are interested in.

Job

By default, **LISTD** will show details for the currently loaded job only. If there is no currently active job and you just type **LISTD** then an error message will be returned.

To show details for all jobs present on the logger, use the **job=*** option. So continuing the previous example:

```
LISTD job=*
 Job      Sch Type       Ov Lg Go  Recs      Capacity
 ======== === ========== == == ==  ========  ========
*SAMPLE   A   Data  Live Y  Y  N         46     34952
*SAMPLE   A   Data  Arc                 38        38
*SAMPLE   B   Data  Live Y  Y  N         23     52428  —
*SAMPLE   B   Alarm Live Y  Y  N          3      1455
*SAMPLE   B   Data  Arc                 19        19
*SAMPLE   B   Alarm Arc                  2         2
 CONFIG   A   Data  Live               204     52428
 CONFIG   B   Data  Live               204     34952

       First                Last                 File
       ===================  ===================  ========================================
       2010-03-01 09:54:23  2010-03-11 19:32:00  B:\JOBS\SAMPLE\A\DATA_A.DBD
       2010-03-01 09:54:23  2010-03-04 18:50:55  B:\JOBS\SAMPLE\002_20100311T193043.DBD
       2010-03-01 09:54:24  2010-03-11 19:32:00  B:\JOBS\SAMPLE\B\DATA_B.DBD
       2010-03-01 09:54:40  2010-03-11 19:32:00  B:\JOBS\SAMPLE\B\DATA_B.DBD
       2010-03-01 09:54:24  2010-03-04 18:50:55  B:\JOBS\SAMPLE\002_20100311T193043.DBD
       2010-03-01 09:54:40  2010-03-01 09:54:48  B:\JOBS\SAMPLE\002_20100311T193043.DBD
       2010-02-19 14:35:25  2010-02-21 00:10:25  B:\JOBS\CONFIG\A\DATA_A.DBD
       2010-02-19 14:35:25  2010-02-21 00:10:25  B:\JOBS\CONFIG\B\DATA_B.DBD
```

The list is now longer because it contains details for another job that happens to be present on the logger, called CONFIG.

Notice also that the job SAMPLE is prefixed by an asterisk (*) to indicate that it is the currently active job.

The Ov, Lg and Go columns are not shown for the CONFIG job, as they only have meaning for the currently active job.

You can also specify an explicit job name for this option, e.g.

```
LISTD job=config
```

Schedule

By default, **LISTD** returns details for all schedules. If you are only interested in a particular set of schedules then the **sched=** option can be used. For example:

```
LISTD job=config sched=B
 Job      Sch Type       Ov Lg Go  Recs      Capacity
 ======== === ========== == == ==  ========  ========  —
 CONFIG   B   Data  Live               204     34952

       First                Last                 File
       ===================  ===================  ========================================
       2010-02-19 14:35:25  2010-02-21 00:10:25  B:\JOBS\CONFIG\B\DATA_B.DBD
```

The value for the **sched** option is actually a list of schedules to include, e.g.

```
LISTD sched=ABK
```

would include details for schedules A, B and K only.

Data and Alarms

By default, **LISTD** returns details for both data and alarm stores. You can restrict it to one or other of these store types using the **data=** and **alarms=** options. These are both yes/no options so you can select just data, just alarms, or both (selecting neither, i.e. **data=N alarms=N**, is generally not useful!)

For example, if you are only interested in alarms:

```
LISTD data=n
 Job      Sch Type       Ov Lg Go  Recs      Capacity
 ======== === ========== == == ==  ========  ========  —
*SAMPLE   B   Alarm Live Y  Y  N          3      1455
*SAMPLE   B   Alarm Arc                  2         2

       First                Last                 File
       ===================  ===================  ========================================
       2010-03-01 09:54:40  2010-03-11 19:32:00  B:\JOBS\SAMPLE\B\DATA_B.DBD
       2010-03-01 09:54:40  2010-03-01 09:54:48  B:\JOBS\SAMPLE\002_20100311T193043.DBD
```

Live and Archive Files

By default, **LISTD** returns details for both live and archive files. You can select which you want to include using the **live=** and **archive=** options. These are both yes/no options and they work in much the same way as the **data=** and **alarm=** options.

Source Drive

Store files may exist on any of the three file system drives – **A:** (USB device), **B:** (internal file system) and **D:** (RAM disk). By default, **LISTD** searches all three drives. Using the **src=** option you can restrict the search to one or more of these drives.

For example, if you are only interested in seeing what store files are on a USB device you can use

```
LISTD src=a
```

Drive letters can be combined, so the default setting is **src=abd**.

Source Path

By default, **LISTD** will search for store files in appropriate folders under **B:\JOBS**, and/or **D:\JOBS** and/or **B:\Sn***serial***JOBS**. The exact search path depends on the **src**, **job** and **sched** option settings.

Alternatively, you can force a particular root folder to search using the **path** option. If this option is set to a valid folder path (which must end in a **** character) then only store files in the specified folder (or any subfolders) will be returned. For example:

```
LISTD path=b:\myarchives\
```

You can also specify a single .DBD file name. **LISTD** will then list the details for just that store file. For example:

```
LISTD path= B:\JOBS\SAMPLE\002_20100311T193043.DBD
```

LISTD Option Summary

The following table summarises the available **LISTD** options:

Option	Value	Description	Default Value
job=	*jobname*	include specified job only	(none)
	*	include all jobs	
	(none)	include current job only	
sched=	*schedule-list*	include specified schedules only	**XABCDEFGHIJK**
data=	**Y** / **N**	include data stores (yes/no)	**Y**
alarms=	**Y** / **N**	include alarm stores (yes/no)	**Y**
live=	**Y** / **N**	include live stores (yes/no)	**Y**
archive=	**Y** / **N**	include archive stores (yes/no)	**Y**
src=	*drive-list*	search for store files on specified drives only	**ABD**
path=	*folder-path*\	search for store files in specified folder or sub-folders only	(none)
	file-path	list details for specified store file only	
	(none)	search path based on **src**, **job** and **sched** options	

COPYD – Unload Data

The **COPYD** command is used to **unload** data and alarms from one or more store files. That is, data is read from the source .DBD file(s), transformed into the desired output format (CSV, DBD etc.), then written to the desired destination (comms port, file, FTP server).

The **COPYD** command supports many options, which are used to:

- select the data or alarm stores from which you wish to unload,
- select the range of data records to unload,
- select the format you want it in,
- select where you want it to go, and
- select what to do with the source data after it has been unloaded.

Selecting the Stores to Unload

The first group of **COPYD** options are used to select the set of data/alarm stores from which to unload. These options are identical to those used for **LISTD**, apart from some different defaults, and are listed in *COPYD Option Summary* *(P99)*.

Note that by default **COPYD** does not unload from archive files – specify **archive=Y** to include them.

Selecting the Range of Data to Unload

The second group of **COPYD** options allow you to further refine the selection of what data to unload, by specifying a time range of interest.

Start and End Times

By default, all available data in the selected data/alarm stores will be unloaded. To select a smaller range, use the **start=** and **end=** options.

- If the **start=** option is specified then only records with timestamp later than or equal to the indicated time will be unloaded.
- If the **end=** option is specified then only records with timestamp less than the indicated time will be unloaded.

The actual start and end times can be specified in a number of different ways. These formats are all based on the ISO8601 time format, which is

yyyy-*mm*-*dd*T*hh*:*mm*:*ss*.*ttt*

Time components may be omitted, starting from the subseconds field. If a time component is not specified then 0 is assumed.

Date components may also be left off, starting with the days field. Missing date components are assumed to be 1. If all date components are omitted then a date of 'today" is assumed.

If just the date part is specified, the trailing **T** is still required, to eliminate any possible ambiguities.

Some examples of possible **start=** and **end=** option values:

Value	Description
2010-02-15T12:05:02.25	12:05:02.25, 15-Feb-2010
2010-02-15T	midnight, 15-Feb-2010
2010-02T	midnight, 01-Feb-2010
13:20	13:20 today
0	midnight today

For example, to unload all data logged between 9:00am and 5:30pm today:

```
COPYD start=9 end=17:30
```

Relative times can also be specified by prefixing either the date or time part with a minus sign.

If the date part is relative, i.e.

-*dd*T*hh*:*mm*:*ss*.*tt*

then this means "the specified time (*hh*:*mm*:*ss*.*tt*), *dd* days ago".

If the time part is relative, i.e.

-*hh*:*mm*:*ss*.*tt*

then this means "the current time, minus the specified offset (*hh*:*mm*:*ss*.*tt*), rounded down to the smallest specified time component"

Some examples may clarify this. These assume that the current time is 17:05:22.888, 20-Feb-2010

Value	Description
-1T17:30	5:30pm yesterday (17:30:00.000, 19-Feb-2010)
-7T	midnight 7 days ago (00:00:00.000, 13-Feb-2010)

-0:10	10 minutes ago, rounded down to the minute (16:55:00.000, 20-Feb-2010)
-2	2 hours ago, rounded down to the hour (15:00:00.000, 20-Feb-2010)
-48	48 hours ago, rounded down to the hour (17:00:00.000, 18-Feb-2010)
-48:00:00.000	exactly 48 hours ago (17:05:22.888, 18-Feb-2010)

Calculated times can be specified by replacing either or both of the date and time parts with channel variable references,
*m***CVT** *hh*:*mm*:*ss*.*tt* or
yyyy-*mm*-*dd***T***n***CV** or
*m***CVT***n***CV**

If a channel variable is used for the date part then the CV value should be in seconds since 1-Jan-1989. The current date, in seconds since 1-Jan-1989, can be obtained using **D(=***m***CV)**.

If a channel variable is used for the time part then the CV value should be in seconds since midnight. The current time, in seconds since midnight, can be obtained using **T(=***m***CV)**.

For example:

Value	Description
1CVT2:30	2:30am on the date specified by 1CV
T22CV	the time specified by 22CV, today
7CVT8CV	the time specified by 7CV, on the date specified by 8CV

Unloading New Data Only

The **start=** option may also be set to the special value of **new**. This will unload all data logged since the last unload.

For example,
RA1H DO{COPYD start=new}
will, every hour, unload all data logged since the last unload.

Unload requests can come from users of the web interface, or users of the command interface, or from schedules in the running job. If these requests specify **start=new** then the question then arises: what was the "last unload"?

The *DT80* is capable of tracking up to 40 "last unload" points – that is, the time at which a particular user last unloaded a particular store.

In order to identify the "user", the **id=** option is used. This is an arbitrary number which is used to track when you last unloaded data from a store.

If this option is not specified then the default setting of **id=0** will be used.

Thus **start=new** really means "unload all data logged since the last time this store was unloaded with this **id** value"

For example, suppose Fred has a USB memory device with the following command in its ONINSERT job (see *ONINSERT Job* *(P59)*)
COPYD start=new id=27 dest=a:

Every time Fred plugs his memory stick into the *DT80*, it will unload all data logged since he last plugged in his device.

Ginger's memory stick contains a similar ONINSERT job:
COPYD start=new id=111 dest=a:

Because Ginger has used a different **id** value, when she plugs in her USB device she will get the data logged since she last plugged in her device.

(This may or may not be the desired behaviour. For example, suppose Fred and Ginger are employed to collect data from the *DT80* on alternate weeks, with both of them bringing the data back to the same central office. In this scenario you would normally use the same **id** value on each device.)

The value used for the **id=** option can be any integer; the only requirement is that it be different for each of the unload "users" between which you want to distinguish.

By default, the **COPYD** command uses a setting of **id=0**. When an unload is done using *dEX* (the web interface), it uses a value of **id=1**. Thus if you choose to specify an **id** value, choose a value other than 0 or 1.

Note The *DT80*'s set of stored "last unload" times will be cleared following a hard reset. If you do a **start=new** unload after a hard reset has occurred then you will receive all available data.

Lost Unload Data

Suppose that after unloading all new data onto his memory stick, Fred then loses it on the way back to the office. When he goes back to the *DT80* with a new memory stick, he needs a way of repeating the last unload he did, so that he gets a new copy of the data he lost, plus anything that has been logged since.

The **start=new2** option can help here. This will unload all data logged since the second last unload command, excluding any **start=new2** unloads.

So to recover the lost data, Fred would use the following command:
COPYD start=new2 id=27 dest=a:
which is the same as his normal command, except with **new2** rather than **new**

If (perish the thought) this unload data was also lost, Fred can simply repeat the same command. This will work because the unload will start from, as stated above, the second last non-**start=new2** unload, which is the same starting point as the original lost unload. Once he successfully gets the data to the office he can go back to using his regular **start=new** command.

Step Size

If you have a very large data set on the logger then it may take considerable time to unload. The **step=** option allows you to download a smaller sample of data points so that you can get a quick overview of the data.

To use this feature, specify **step=***interval*, where *interval* is the required minimum time interval between successive samples.

For example, the following schedule executes every 100ms so it will log 864,000 samples per day (approx. 20MB)

```
RA(DATA:1D)100T 1V
```

To get a quick picture of the day's data you could download samples at, say, 10s intervals rather than 100ms, which would result in a more manageable 8640 data points. The command for this would be:

```
COPYD step=10
```

Fractional times can also be specified, e.g. **step=2.5**, which would set the minimum interval between unloaded samples to 2.5 seconds.

Note also that the *DT80* is returning the original samples, just fewer of them. It is not performing any averaging or minimum/maximum detection, so by using the **step=** option you may miss peaks in the data.

Selecting the Data Format

The third group of **COPYD** options is concerned with the format of the unloaded data.

Data Format

Data and alarms can be unloaded in one of four different formats:

- CSV format (Comma Separated Value). This is the default. CSV files can be imported into any spreadsheet or data analysis package.
- DBD format. Unloading in this binary format creates an **archive file**, from which you can then unload at a later date. DBD files can also be opened by certain PC data analysis packages.
- fixed format. This text-based format is similar to CSV, and can be read by applications such as *DeLoad*.
- free format. This text-based format can be customised using the *DT80*'s switch and parameter settings.

These formats are described in more detail in *Format of Returned Data* *(P25)*.

To set the **COPYD** output format, use the **format=** option, which may be set to **csv**, **dbd**, **fixed** or **free**.

Note Unloading in any of the text based formats (CSV, fixed or free) is significantly slower than unloading in DBD format. If you have very large store files then you may prefer to unload to DBD, transfer the DBD file(s) to the PC, and then use a utility such as *dump_dbd* (or other DBD-aware application) to convert to CSV, rather than doing the conversion on the *DT80*.

Merged Files

By default, **COPYD** will merge data from the selected store files into a single output file. This is not a true "merge", in that duplicate records are not eliminated, and records in the resulting file will not necessarily be in time order. However, these issues are relatively easy to deal with using a host tool such as a spreadsheet package.

For example, suppose there are two jobs on the logger, HEDGEHOG and ECHIDNA. The former has one schedule (A), with logged data and alarms. ECHIDNA has a two schedules, J and K, with logged data only. Some time ago an archive file was generated for ECHIDNA.

The source store files on the logger are therefore:

```
B:\JOBS\HEDGEHOG\A\DATA_A.DBD  (data and alarms for HEDGEHOG schedule A)
B:\JOBS\ECHIDNA\J\DATA_J.DBD  (data for ECHIDNA schedule J)
B:\JOBS\ECHIDNA\K\DATA_K.DBD  (data for ECHIDNA schedule K)
B:\JOBS\ECHIDNA\000_20091225T123409.DBD  (archive file containing ECHIDNA J & K data snapshot)
```

We now wish to retrieve all available data to a USB memory device:

```
COPYD job=* archive=Y dest=a:
```

This will then create a single output file:

```
A:\SN081234\JOBS\001_20100313T181008.CSV
```

This file will contain, in order, the following elements:

- a CSV header row for all of ECHIDNA's channels: J data, K data
- schedule J data values from live store file
- schedule J data values from archive file
- schedule K data values from live store file
- schedule K data values from archive file
- a CSV header row for all of HEDGEHOG's channels: A data, A alarms

- schedule A data values
- schedule A alarm values

It is also possible to unload to separate files, by adding an option:

```
COPYD job=* archive=Y dest=a: merge=N
```

This will then create output files similar to the following:

A:\SN081234\JOBS\ECHIDNA\J\001_20100313T181008.CSV (J data from live store file)
A:\SN081234\JOBS\ECHIDNA\K\002_20100313T181008.CSV (K data from live store file)
A:\SN081234\JOBS\ECHIDNA\J\000_20091225T123409.CSV (J data from archive file)
A:\SN081234\JOBS\ECHIDNA\K\000_20091225T123409.CSV (K data from archive file)
A:\SN081234\JOBS\HEDGEHOG\A\003_20100313T181008.CSV (A data and alarms)

Notice that the archive file (which was originally created by merging data from J and K schedules) has now been "unmerged" into its constituent schedules. Also notice that for data sourced from archive files, the original archive file name is preserved (apart from the file extension, which was changed to **.CSV** to suit the new file format).

Merging works in a similar way for other output formats (DBD, fixed and free) – the various parts are combined in the same order as for CSV.

Selecting the Unload Destination

The **dest=** option is used to specify where the unloaded data should go. The four broad choices are:

- display the data, i.e. return it to the active comms port on which the **COPYD** command was sent. This is the default for text-based unload formats. It is not applicable for DBD format unloads, as DBD is a binary format.
- write it to file(s) on the internal file system. This is the default for DBD format unloads.
- write it to file(s) on a USB memory device
- upload the data to an FTP server

To display the data interactively, no option is required as this is the default. For example, just typing

```
COPYD
```

will unload all data for the current job to the active comms port, in CSV format.

During an unload to the active comms port, the *DT80* disables real time data and alarm return, command echo and error messages, to prevent these messages being mixed in with the unload stream. These functions will be re-enabled once the unload completes.

Local Files

To output to a file or files in the default location on the internal file system, use **dest=B:**. The actual folder(s) used depend on the **job=** and **merge=** settings:

job	merge	Destination folder
job=*	**merge=y**	**B:\JOBS**
job=*jobname* (or omitted)	**merge=y**	**B:\JOBS***jobname*
job=*	**merge=n**	**B:\JOBS***job**sched*
job=*jobname* (or omitted)	**merge=n**	**B:\JOBS***jobname**sched*

Each file created will have an auto-generated filename which identifies the time that the unload took place, e.g. **001_20100910T120900.csv**. (The **001_** is a sequence number.)

The same goes for unloading to a file on the USB memory device, except that this time you would use **dest=A:**. Files will then be written to **A:\Sn***serial-num***\JOBS** or a subfolder of this, depending on the options.

You can also specify an alternative destination folder, e.g.

```
COPYD dest=B:\mydir\x1\
```

(Note that the trailing backslash is required), which will operate as follows:

job	merge	Destination folder
job=*	**merge=y**	**B:\mydir\x1**
job=*jobname* (or omitted)	**merge=y**	**B:\mydir\x1**
job=*	**merge=n**	**B:\mydir\x1***job**sched*
job=*jobname* (or omitted)	**merge=n**	**B:\mydir\x1***sched*

Finally, you can also specify an explicit destination file name, e.g.

```
COPYD dest=a:\mydir\data2009.dbd
```

This form is not valid for **merge=N** unloads.

FTP Server

The *DT80* is also able to unload data to files on a remote server, using FTP (File Transfer Protocol).

An FTP transfer is initiated by specifying an **FTP Uniform Resource Identifier** (URI) as the value of the **dest=** option. This URI has the form:

ftp://*username***:***password***@***host-ip***/***pathname*

where:

- ***username*** is the user name to use when logging in to the FTP server
- ***password*** is the password to use when logging in to the FTP server
- ***host-ip*** is the IP address of the computer running the FTP server. This may be specified in numeric form (e.g. **192.168.1.23**), or as a domain name (e.g. **ftp.datataker.com**).
- ***pathname*** is the path (and, optionally, filename) into which to write the unloaded data.

For an FTP transfer, the destination folder(s) are created in the same way as for a local unload. For example:

```
COPYD job=CAT9 dest=ftp://harryp:snitch@ftp.hsww.edu/transfig/
```

In this example, the *DT80* will log in to the FTP server **ftp.hsww.edu** using the username **harryp** and the password **snitch**, create the folder **/transfig/CAT9**, then unload all data for the CAT9 job to a file such as **002_20100314T090500.CSV** in that folder.

If an explicit filename is specified (valid for **merge=Y** unloads only) then data will be written to that file, e.g.

```
COPYD dest=ftp://harryp:snitch@ftp.hsww.edu/transfig/my%20data.csv
```

Note When retrieving logged data by unloading it to an FTP server there must be sufficient space available on the *DT80* internal flash drive to create a temporary file prior to sending to the server. The space required will depend on the amount of data being unloaded. If you unload the entire contents of a 10MB storefile to FTP in DBD format then you will need 10MB free for the temporary file. If you unload in CSV format then the space required will be of the order of 10MB, but may be less or more depending on the data values.

If an FTP transfer fails, the *DT80* will automatically retry two more times, with a one minute delay between each attempt. If all three attempts fail then the unload will be abandoned and the temporary file will be deleted.

All FTP failures are logged to the *DT80* event log; see *Event Logs* (P213).

Note also that:

- The specified host computer must be accessible to the *DT80*. That is, it must either be on the same local network segment, or it must be reachable using the *DT80*'s configured **gateway** address (see *Gateway* (P180)).
- The *DT80* always uses **passive mode** FTP transfers. Passive transfers are less likely to cause problems with network firewalls.
- If there are special characters, e.g. **@** or space, in the username or filename parts of the URI then they must be **escaped**, i.e. replaced by a special numeric sequence. Spaces should be replaced with **%20** (as in the above example), while **@** characters should be replaced with **%40**.
- If the FTP server is specified by name (rather than numeric IP address) then a DNS (Domain Name Service) server must be available to the *DT80*. See*Setting Ethernet Parameters* (P182).

Other Options

The final **COPYD** option is **delete=**. If this is set to **Y** then following a successful unload, the records just unloaded will be deleted from the source DBD file.

In most cases there is no benefit in doing this, and it would also mean that for example the **start=new2** feature would no longer work because the data will no longer be present on the logger.

This option may however be useful if you have a **NOV** (no overwrite) store file, or if you want to create archive files (possibly in response to events) where there is no overlap between successive archive files.

Option Conflicts

Certain combinations of **COPYD** options are invalid, and will result in a "parameter/option conflict" error message. In particular:

- If **format=dbd** then the **step=** option is not supported. All records in the specified time range will be unloaded.
- If **format=dbd** then **dest=stream** is not valid: DBD format data can only be output to a file (either local or on an FTP server). If DBD format output is specified then the default value of **dest** is **B:** rather than **stream**.
- If **merge=n** then **dest=stream** and **dest=***filename* are invalid: given that multiple output files are to be created, the destination must resolve to a folder.

- If **start=new** or **end=new** (or **new2**) then the **job=** option is invalid: tracking of the last unloaded record is only supported for the current job.
- If **delete=y** then the **start=** option is invalid: data are always deleted from the start of the storefile

COPYD Option Summary

The following table summarises the available **COPYD** options:

Option	Value	Description	Default Value
Store selection options			
job=	*jobname*	Unload specified job only	(none)
	*****	Unload all jobs	
	(none)	Unload current job only	
sched=	*schedule-list*	Unload specified schedules only	**XABCDEFGHIJK**
data=	**Y** / **N**	Unload data (yes/no)	**Y**
alarms=	**Y** / **N**	Unload alarms (yes/no)	**Y**
live=	**Y** / **N**	Unload from live stores (yes/no)	**Y**
archive=	**Y** / **N**	Unload from archive stores (yes/no)	**N**
src=	*drive-list*	Search for store files on specified drives only	**ABD**
path=	*folder-path*****	Search for store files in specified folder or sub-folders only	(none)
	file-path	Unload from specified store file only	
	(none)	Search path based on **src**, **job** and **sched** options	
Data Range options			
start=	*yyyy***-***mm***-***dd***T***hh***:***mm***:***ss***.***tt*	Unload records later than or equal to specified timestamp. Date/time components may be omitted, starting with least significant.	start with oldest logged record
	-*dd***T***hh***:***mm***:***ss***.***tt*	timestamp is specified time, *dd* days ago	
	-*hh***:***mm***:***ss***.***tt*	timestamp is current time, minus the specified offset, rounded down to the smallest specified time component	
	*m***CVT***hh***:***mm***:***ss***.***tt*	date part of timestamp is *m*CV value (seconds since 1-Jan-1989)	
	*yyyy***-***mm***-***dd***T***n***CV**	time part of timestamp is *n*CV value (seconds since midnight)	
	*m***CVT***n***CV**	date and time parts of timestamp given by *m*CV and *n*CV	
	new	Unload new records logged since the last unload of this store with the same **id** value	
	new2	Unload new records logged since the second-last unload (excluding **start=new2** unloads) of this store with the same **id** value	
end=	as for **start=**, except **new**, **new2**	Unload records earlier than specified timestamp	end with latest logged record
id=	*integer*	Arbitrary user identifier for tracking last unload time	**0**
step=	*number*	Minimum time interval between successive unloaded records (0 = unload all records)	**0**
Output Format options			
format=	**csv**, **dbd**, **fixed**, **free**	Unload data in the specified format	**csv**
merge=	**Y** / **N**	Generate a single merged output file (yes/no)	**Y**
Unload Destination options			
dest=	**stream**	Unload to active comms port (CSV/fixed/free format only) (requires **merge=Y**)	**stream** (CSV/fixed/free), or **B:** (DBD)
	B:	Unload to **B:\JOBS** and/or subfolders	
	A:	Unload to **A:\Sn***serial-num***\JOBS** and/or subfolders	
	*path*****	Unload to *path* and/or subfolders	
	*path******filename*	Unload to file *filename* (requires **merge=Y**)	
	ftp://*user***:***pwd***@***ip***/***path***/**	Unload to *path* on FTP server and/or subfolders	
	ftp://*user***:***pwd***@***ip***/***path***/***filename*	Unload to file *filename* on FTP server (requires **merge=Y**)	
Other options			
delete=	**Y** / **N**	Delete records from source files after successful unload	**N**

Aborting an Unload

The **Q** (quit unload) command can be used to abort all current and pending **COPYD** unloads. It has no effect on unloads initiated via the Retrieve Data function in *dEX*.

Detecting Unload Status

The system variable 29SV can be used to determine the success or otherwise of the last **COPYD** command.

29SV	Meaning
0	No unloads have been attempted
1	Unload in progress
2	Last unload was successful
-1	FTP connection error: can't find server name (name invalid or can't connect to DNS server)
-2	FTP connection error: can't connect to server (computer not present or no FTP server running)
-3	FTP connection error: unexpected response from server (rare)
-4	FTP connection error: invalid username
-5	FTP connection error: invalid password
-6	FTP connection error: error selecting binary mode on server (rare)
-7	FTP connection error: error creating or changing to specified directory on server (user may not have permission to create directories)
-10	FTP transfer error: no response from server (server may be overloaded)
-11	FTP transfer error: could not create the destination file (directory or read-only file exists with same name)
-12	FTP transfer error: could not open data connection (server may be overloaded)
-13	FTP transfer error: could not read file from logger disk (rare)
-14	FTP transfer error: server aborted transfer (server may have been shut down)
-15	FTP transfer error: error sending or receiving (connection may have dropped out)
-16	File transfer error: could not open destination file (directory or read-only file exists with same name)
-17	File transfer error: could not write to file (disk may be full)
-20	Source store file error: problem accessing file
-21	Source store file error: store file is corrupted
-22	Source store file error: some other problem
-99	Unload was aborted by user (**Q** command)

For example, the following program will scan a thermocouple once a minute and unload data to an FTP server once a day. If the transfer fails then it will retry indefinitely at 10 minute intervals. Schedule C checks whether a retry is required by polling 29SV – if it is found to be negative then Schedule B is retriggered, using the **XB** command.

```
BEGIN"JOB1"
 29SV(W)=0
 RA1M 1TK LOGONA
 RB1D DO{COPYD start=new dest=ftp://ronw:carrot@ftp.hsww.edu/dada/}
 RC10M IF(29SV(LM,"FTP status")<0){XB} LOGONC
END
```

Further COPYD Examples

Precise hourly data ranges

The following fragment will unload hourly data to an FTP server with the boundaries of each unload occurring precisely on the hour. This is achieved by using the **end=-0** option. This time value has a leading minus sign, so it is interpreted as a relative time. An offset of 0 means "now", but recall that one of the properties of a **COPYD** relative time spec is that the time is rounded down to the start of the smallest specified time interval. In this case only the hours part of the time has been specified, so the resulting time will be rounded down to the start of the hour.

```
RA1H DO{COPYD start=new end=-0 dest="ftp://blah.fr/leData.csv"}
```

Capturing Pre-Trigger Data Using Archive Files

Archive files can be used for applications such as capturing **pre-trigger data** leading up to some event. For example:

```
BEGIN"SPARROW"
1..2CV(W)=0
RA(DATA:200R:OV)1S 2V
 ALARM(1DS(LM)==0){2CV=1}
 1CV(W)=1CV+2CV
 IF(1CV>100){1..2CV(W)=0; COPYD format=dbd}
LOGONA
END
```

In this example, a small store file is declared for schedule A (capacity 200 records). The channel of interest (**2V**) is measured

and logged once per second, with old values being overwritten. When digital input **1D** (**1DS**) goes low we counting samples, accumulating the count in 1CV. After a further 100 samples have been taken schedule A will then execute the **COPYD** command, which will create an archive file on the local file system. The end result is that each archive file that is created will contain 100 samples taken just prior to the trigger event, and 100 samples taken immediately after.

Note If data are being logged at a relatively fast rate, the earliest samples may be overwritten before they can be copied into the archive file, which may result in fewer than expected pre-trigger records being present in the archive file. In the above example there might be 198 samples in the archive (98 pre-trigger, 100 post-trigger)

If you need to have exactly the right number of samples then you should halt sampling for the duration of the archive operation, i.e.:

```
IF(1CV>100){1..2CV(W)=0; HA; COPYD format=dbd; GA}
```

DELD - Delete Logged Data

The **DELD** command is used to **delete** data and alarms from one or more store files.

The **DELD** command options are used to:

- select the data or alarm stores from which you wish to delete records
- select the range of data records to delete

The options used to select the set of data/alarm stores from which to delete are identical to those used for **LISTD**, apart from some different defaults, and are listed in *DELD Option Summary* *(P102)*.

Note that by default **DELD** does not delete archive files – specify **archive=Y** to include them.

You can specify a range of data to delete using the **end=** option, which works in the same way as the equivalent **COPYD** option. That is, you can delete all data older than the specified time.

Note that **DELD** does not support the **start=** option.

For example, to delete all logged data for the current job which is older than 30 days, including data in archive files, use:

```
DELD archive=Y end=-30T
```

Some points to note:

- Once the required records have been deleted from an archive file, if the archive file is then empty then the file will be deleted.
- Live store files are not deleted, even if all records have been deleted.
- If any orphan store files are found (live or archive) then they will be deleted.

DELD Option Summary

The following table summarises the available **DELD** options:

Option	Value	Description	Default Value
Store selection options			
job=	*jobname*	Delete records for specified job only	(none)
	*	Delete records for all jobs	
	(none)	Delete records for current job only	
sched=	*schedule-list*	Delete records for specified schedules only	**XABCDEFGHIJK**
data=	**Y** / **N**	Delete data (yes/no)	**Y**
alarms=	**Y** / **N**	Delete alarms (yes/no)	**Y**
live=	**Y** / **N**	Delete from live stores (yes/no)	**Y**
archive=	**Y** / **N**	Delete from archive stores (yes/no)	**N**
src=	*drive-list*	Search for store files on specified drives only	**ABD**
path=	*folder-path*\	Search for store files in specified folder or sub-folders only	(none)
	file-path	Unload from specified store file only	
	(none)	Search path based on **src**, **job** and **sched** options	
Data Range options			
end=	*yyyy-mm-dd***T***hh:mm:ss.tt*	Delete records earlier than specified timestamp. Date/time components may be omitted, starting with least significant.	delete all records
	*-dd***T***hh:mm:ss.tt*	timestamp is specified time, *dd* days ago	
	-hh:mm:ss.tt	timestamp is current time, minus the specified offset, rounded down to the smallest specified time component	
	*m***CVT***hh:mm:ss.tt*	date part of timestamp is *m*CV value (seconds since 1-Jan-1989)	
	*yyyy-mm-dd***T***n***CV**	time part of timestamp is *n*CV value (seconds since midnight)	
	*m***CVT***n***CV**	date and time parts of timestamp given by *m*CV and *n*CV	
	new	Delete records logged prior to the last unload of this store with the same **id** value	
	new2	Delete records logged prior to the second-last unload (excluding **start=new2** unloads) of this store with the same **id** value	
id=	*integer*	Arbitrary user identifier for tracking last unload time	**0**

Deleting Store Files

Deleting Jobs

A job's store files are physically deleted when the job is deleted using **DELJOB** (see *Deleting Jobs* *(P58)*). However, note that as a safeguard against accidental deletion, you first need to "empty" the store files using **DELD** .

Therefore, to delete all trace of job WEST3, you could send the following sequence:

```
DELD j=west3
Deleting: WEST3 A Data
Deleting: WEST3 B Alarms
DELJOB "west3"
Deleting: WEST3
Done
```

Deleting All Jobs

The **DELALLJOBS** command is a quick way of deleting all jobs and their store files.

This command will:

- halt and delete the current job, including any logged data and alarms
- delete all other stored jobs and logged data, i.e. all files under the **B:\JOBS** directory.

Note that the program files for any locked jobs will not be deleted. Use the **UNLOCKJOB** command first.

Background Commands

DT80 commands are normally executed sequentially – if you type two commands in quick succession then the second one will not be carried out until the first command has been completed.

However, if a large amount of data has been logged then the **COPYD** command can take a significant amount of time to execute. This could potentially cause subsequent commands to be delayed for a long time, which is undesirable in many applications.

To address this problem, the **COPYD** command is designated as a **background command**. Background commands can execute "in parallel" with other commands.

When a background command is started (e.g. you type **COPYD**), the transfer will commence but you will notice that the DT80> prompt is returned immediately, indicating that further commands may be entered and they will be acted on immediately, even though the unload operation is still in progress. Similarly, if an **ALARM** statement triggers an action command then it will be executed immediately, without having to wait for the background command to complete.

There are situations, however, where sequential execution is required. For example, it is common to execute a **COPYD dest=a:** command to copy logged data to a USB memory device, followed by a **REMOVEMEDIA** command to shut down the USB port to allow the memory device to be removed. Clearly the **REMOVEMEDIA** command can only be carried out once the **COPYD** command has finished.

The *DT80* uses the following rules:

1. A sequence of commands on the same command line always executes sequentially. So if you enter:
   COPYD; HA; COPYD; SATTN
   all on the one line, or if you include them all in a single alarm command string, e.g.
   RA1D DO{ COPYD; HA; COPYD; SATTN }
   then the **HA; COPYD; SATTN** commands will be delayed until the first **COPYD** completes.
2. If a background command is in progress and you attempt to execute another background command then the new command will be delayed until the first command completes. Because of Rule 1, any commands that occur after the new command on the same command line will also be delayed.

For example, the command line
COPYD dest=A:; REMOVEMEDIA
will operate as expected, i.e. the **REMOVEMEDIA** will not be executed until the copy completes.

By contrast,
COPYD dest=A:
REMOVEMEDIA
will likely cause various error messages to be returned, because the **REMOVEMEDIA** will execute in parallel with the **COPYD**, causing the memory device to be shut down prematurely.

Simultaneous Unloads

Because of Rule 2 above, only one **COPYD** command can execute at any one time – if you or your job tries to start a second then it will remain pending until the first unload completes.

It is permissible, however, to perform a web unload (using the *dEX* **Retrieve Data** function) at the same time as a **COPYD** unload or another web unload.

Obsolete Commands

The **COPYD**, **LISTD** and **DELD** commands replace a number of other unload related commands. These commands are still supported but are considered obsolete and may be removed in future firmware versions.

The following table lists the commands (not all possible combinations are shown), and their current equivalents.

Old command	Replacement
U	**COPYD format=free alarms=N src=AB**
A	**COPYD format=free data=N src=AB**
/H U	**COPYD format=fixed alarms=N src=AB**
U*sch*	**COPYD format=free alarms=N src=AB sched=***sch*
U"*job***"***sch*	**COPYD format=free alarms=N src=AB sched=***sch* **job=***job*
U"*job***"***sch* **(***start***) (***end***)**	**COPYD format=free alarms=N src=AB sched=***sch* **job=***job* **start=***start* **end=***end* (format of *start* and *end* is a little different)
U"*job***"***sch* **"***ftp-URI***"**	**COPYD format=free alarms=N src=AB sched=***sch* **job=***job* **dest=***ftp-URI*
COPYDATA	**COPYD format=dbd archive=Y src=B dest=A:**
MOVEDATA	**COPYD format=dbd archive=Y src=B dest=A: delete=Y**
ARCHIVE	**COPYD format=dbd src=B dest=B:**
DIRJOB	**LISTD archive=N**
DIRJOB*	**LISTD archive=N job=***
DELDATA	**DELD alarms=N**
DELALARMS	**DELD data=N**

The DT80 *File System*

Internal File System (B:)

The *DT80* uses a Windows compatible FAT16/FAT32 file system for storing logged information (data and alarms) and system information. The internal file system uses flash memory, so all files will be preserved even if the *DT80* is reset or loses all power. The size of this file system for a standard *DT80* is 128Mbyte.

The internal file system is used to store information such as:

- program text for stored jobs (e.g. **B:\JOBS\MYJOB\PROGRAM.DXC**)
- store files (e.g. **B:\JOBS\MYJOB\A\DATA_A.DBD**)
- archive files (e.g. **B:\JOBS\MYJOB\A\009_20100401T090002.DBD**)
- other unload output files (e.g. **B:\MYDATA\MYJOB\A\021_20100101T190012.CSV**)
- current profile settings (**B:\INI\USER.INI**)
- system event and/or error logs (**B:\EVENTS\EVENT.LOG** and **ERROR.LOG**)
- web interface files (e.g. **B:\WWW\index.html**)
- documentation files (e.g. **B:\DOC\DT8x Users Manual.pdf**)

Note Path and file names shown above are for illustrative purposes only, and may change in future firmware revisions.

A typical directory listing (see *File Commands* *(P106)*) of the internal file system might look like:

```
DIRTREE B:
Volume in drive B has no label.

 2006/02/06 12:13     133120 <RO>       -  FAILSAFE
 2006/02/06 12:13                <DIR>  -  EVENTS
 2006/02/08 12:17       1501            -    EVENT.LOG
 2006/02/06 12:36                <DIR>  -  INI
 2006/02/08 10:56        199            -    USER.INI
 2006/02/07 10:50        213            -    USER.BAK
 2006/02/06 12:14                <DIR>  -  JOBS
 2006/02/06 15:17                <DIR>  -    SPARROW
 2006/02/06 15:17                <DIR>  -      A
 2006/02/06 15:56       4208            -        DATA_A.DBD
 2006/02/06 15:19       3028            -        001_20060206T151936.DBD
 2006/02/06 15:56       4208            -        002_20060206T155654.DBD
 2006/02/06 16:33       4208            -        003_20060206T163356.DBD
 2006/02/07 13:02        138            -      STATUS14
 2006/02/07 13:02        121            -      PROGRAM.DXC
 2006/02/06 16:01                <DIR>  -    UNTITLED
 2006/02/08 10:53         95            -      STATUS14
 2006/02/08 10:53         41            -      PROGRAM.DXC
 2006/02/07 13:03                <DIR>  -    DTCAN169
 2006/02/07 13:03                <DIR>  -      A
 2006/02/07 13:03    1051584            -        DATA_A.DBD
 2006/02/07 13:03                <DIR>  -      D
 2006/02/07 13:03    1049104            -        DATA_D.DBD
 2006/02/07 13:03       3466            -      STATUS14
 2006/02/07 13:03      17523            -      PROGRAM.DXC
           25 File(s)   63074304 Bytes free
```

In this example there are three jobs stored on the *DT80*: `SPARROW` (one schedule; three archive files have been created at various times; in the case of the first one the store file was not yet full at the time it was created, hence its size is smaller than the others), `UNTITLED` (no schedules have logging enabled, hence no store files) and `DTCAN169` (two schedules with logged data).

External USB Devices (A:)

An external USB memory device plugged into the *DT80* can be used to store:

- store files (e.g. **A:\SN081234\JOBS\MYJOB\A\DATA_A.DBD**) for schedules that are configured to log directly to the USB device (using the **"A:"** schedule option)
- archive files (e.g. **A:\SN081234\JOBS\MYJOB\A\001_20060401T090002.DBD**)
- an ONINSERT job (**A:\SN081234\ONINSERT.DXC**) which will run when the memory device is inserted into this *DT80*
- an ONINSERT job (**A:\ONINSERT.DXC**) which will run when the memory device is inserted into any *DT80*
- other files which have been manually copied from the *DT80*, e.g. event logs
- other files not related to the *DT80*

Notice that *DT80* related files are always stored in a subtree whose name is based on the *DT80* serial number. This allows data from a number of different *DT80*s to be collected on the one USB device.

A typical directory listing (see *File Commands* (P106)) of a USB device might look like:

```
   DIRTREE A:
Volume in drive A is JD1

    2006/02/06 12:40                <DIR> -  SN080043
    2006/02/06 12:40                <DIR> -    JOBS
    2006/02/06 12:40                <DIR> -      UNTITLED
    2006/02/06 12:40                <DIR> -        A
    2006/02/06 12:40    1048784           -          DATA_A.DBD
    2006/02/07 13:36                <DIR> -      DTCAN169
    2006/02/07 13:36                <DIR> -        A
    2006/02/07 13:36       8928           -          001_20060207T133615.DBD
    2006/02/07 13:36                <DIR> -        D
    2006/02/07 13:36       4788           -          002_20060207T133615.DBD
    2006/01/27 10:46                <DIR> -  SN080122
    2006/01/27 10:46        202           -    ONINSERT.DXC
    2006/02/07 17:46                <DIR> -    JOBS
    2006/02/07 17:46                <DIR> -      XAM
    2006/02/07 17:46                <DIR> -        A
    2006/02/07 17:46    1048784           -          DATA_A.DBD
    2006/02/07 17:46                <DIR> -        B
    2006/02/07 17:46    1048784           -          DATA_B.DBD

              18 File(s)    125306880 Bytes free
```

In this case the memory device has been used in two different *DT80*s. Serial number 080043 has logged some data directly to the device as part of job UNTITLED, while archive files have been created for job DTCAN169 – probably using **COPYDATA**. Serial number 080122 has logged data directly to store files on the device, and it also has an ONINSERT job defined, which will run whenever the memory device is plugged into *DT80* serial number 080122.

Supported USB Device Types

For an external USB memory device to be recognised by the *DT80*, the device must:

- draw no more than 100mA from the USB bus, and
- support the standard USB "mass storage" device class interface (this includes most USB "memory sticks", MP3 players and USB hard disks, but does not include devices such as USB printers, modems and so on), and
- have the primary disk partition formatted using a FAT16 or FAT32 file system.

USB memory devices are nearly always shipped pre-formatted using a FAT16/FAT32 file system.

If a memory device is inserted that is not properly formatted, the *DT80* will display:

```
   USB device unrecognised
```

on the LCD.

Formatting a USB Memory Device

The **FORMAT A:** command (see *File Commands* (P106)) can be used to re-format the device. This will delete all data from the device. Alternatively the device can be formatted in a Windows based computer.

Note For larger capacity USB memory devices (1Gbyte and above), it is recommended that you always format the device in the logger before using it for the first time. This is because the *DT80* will format the device in a way that maximises performance and minimises the time taken to read the device each time it is inserted. In particular:

- for capacities in the range 1-2GB, the *DT80* will create a **FAT16** file system, whereas Windows will normally format the device as **FAT32** by default. FAT16 is less space-efficient if there are many small files, but it is faster.

- for capacities 4GB and above, the *DT80* will create a **FAT32** file system. It will, however, select a larger allocation unit size to maximise speed at the expense of space efficiency.

Note that even though Windows and the *DT80* may use different formatting parameters, Windows will always be able to read a *DT80*-formatted device, and vice versa.

Using a USB Memory Device

Startup

When a USB memory device is first plugged in, the *DT80* needs to read various information from the device before it can be used. This process can take several seconds (possibly a minute or more for large media), but it is a background operation so sampling and logging can continue. The *DT80* displays

```
Reading USB device
```

on the LCD while this operation is in progress.

Once the USB device is ready, it can be accessed in the same way as the internal drive.

Removal

Important The USB device must not be removed while it is being accessed. Doing so may result in data corruption.

To safely remove a USB device, you should always first issue the **REMOVEMEDIA** command. This command is also one of the default options on the front panel function menu *(P111)*. This command will:

1. suspend logging for any schedules that are configured to log directly to the USB memory device. This will cause an error message to be returned, and the **Attn** LED will start flashing.
2. make sure that all required information has been fully copied to the device and all files are closed
3. shut down the device. If the device has an indicator light, it should now be off.

If you change your mind and want to keep using the device, you will now need to remove it and then re-insert it.

File Commands

The *DT80* provides a number of general purpose file manipulation commands. These will work both for files stored on the internal file system (**B:**) and an external USB memory device (**A:**), if one is present.

Command	Function
COPY *source dest*	reads the file *source* and creates a copy called *dest*. If *dest* is a folder name (i.e it ends with a **** character) then a file will be created with the same name as the source.
COPY *source ftp-URI*	uploads the file *source* to the FTP server pathname specified by *ftp-URI*
DIR *path*	lists the contents of directory *path*. If *path* is not specified, **B:** is assumed.
DIRTREE *path*	lists the contents of directory *path* and all sub-directories. If *path* is not specified, **B:** is assumed.
TYPE *source*	displays the contents of file *source*. Use only with text files.
DEL *source*	deletes the file *source*. Use with care!
DELTREE *path*	deletes the directory *path* and all subdirectories. Use with care!
FORMAT A:	deletes all files from the USB memory device and re-creates the file system. Use with care! For best performance, it is recommended that new USB devices be formatted in the *DT80* before use.
FORMAT B: DELETEALL	deletes all files from the internal flash drive and re-creates the file system. This command would normally only ever be used if the *DT80*'s internal compact flash card was replaced. After executing this command it will be necessary to repeat the firmware upgrade process in order to re-install system files (e.g. for the web interface) onto the internal flash drive.

Note These commands are for advanced users only. In most cases the standard *DT80* commands (e.g. **LISTD**, **DELD** and so on) are preferred. Furthermore, note that file names or locations may be subject to change in future firmware versions.

The *DT80*'s default directory is **B:**. So the command **DIR JOBS** is equivalent to **DIR B:\JOBS**.

For example, if you want to copy the *DT80*'s system event log to a USB memory device for later analysis you could use:

```
COPY EVENTS\EVENT.LOG A:\EVENT_20060219.LOG
Done
```

Note that **wildcards** (e.g. **"*.LOG"**) are not supported by any of these commands.

Important The *DeTransfer* program, which is often used to supervise the *DT80*, has a number of special commands that begin with a **** (backslash) character. These are interpreted by *DeTransfer* and not sent to the *DT80*. In order to send a **** character from *DeTransfer*, you need to enter a double backslash (****). For example, the above example would be entered into *DeTransfer* as follows:

```
COPY EVENTS\\EVENT.LOG A:\\EVENT_20060219.LOG
```

This rule applies to *DeTransfer* only; it does not apply to the "Text" window in *DeLogger*, nor to the web interface Command window.

Data Recovery

Prevention

If you accidentally remove a USB device while it is being accessed, then it is possible that the file system on the USB device may be corrupted. (The same applies if you remove a USB memory device from a Windows computer without selecting the "Safely Remove Hardware" option.)

The internal file system or USB memory device may also be corrupted if the logger suddenly loses all power while it is writing to the disk.

To minimise the chance of data loss due to these causes, remember to:

- ensure that the battery link is in place. This will allow the *DT80* to keep operating normally for a period of time, in the event of an external power failure
- always use the **REMOVEMEDIA** command before removing the memory device if there are schedules logging directly to the USB device

Note that the *DT80* provides some protection against gradual power failure (e.g. the internal battery becoming discharged). If it detects that the supply voltage is becoming critically low, the *DT80* will automatically close all store files and force the unit into low power **sleep** mode *(P231)*. The *DT80* will remain asleep until the power supply recovers to an adequate level.

Recovery

Media Removal

If a USB device was accidentally removed while it was being logged to, you should plug it into a Windows computer. Before attempting to open any of the files, run a Windows file system check utility (e.g. type **chkdsk** *drive*: at a command prompt, where *drive* is the drive letter assigned to the USB device). This will detect and if possible repair any inconsistencies in the file system structure.

Note that even if there are no file system errors, there may still be corruption in one or more store files (**DATA_***x***.DBD**) if they were being actively logged to at the time of the media removal. Copy the files to the host PC and verify that they can be opened successfully and all the expected data is there.

If the files appear to be damaged (e.g. they don't open correctly in *dump_dbd*) then the original files on the USB device should be deleted before inserting the device back into the *DT80* and re-enabling logging. This avoids having the *DT80* attempt to log data to a damaged file, possibly causing more damage in the process.

Power Failure

If external power was lost and the battery link was not present or the internal battery was flat, then the internal file system may be corrupted (if it was being written to at the time of the failure).

When power is restored, the *DT80* will attempt to automatically repair the file system (using the **B:\FAILSAFE** file) if necessary.

Before re-enabling logging, it would be prudent to manually copy to a USB device the store files for the job that was active at the time of the failure, e.g.:

```
COPY B:\JOBS\JOE\A\DATA_A.DBD A:\JOE_SAVE\DATA_A.DBD
```

and verify that they can be opened on the host PC.

Store File Recovery

If a store file is damaged, contact Datataker for assistance. We may be able to recover data from the file. But note that prevention is always better than cure.

Badly Formatted Device

In exceptional cases, a severely corrupted memory device may result in a fatal error occurring on the *DT80* when the device is inserted, and this may cause the *DT80* to reset. If this is the case, you can try holding down the **Func/Cancel** button while inserting the memory device. This will cause the *DT80* to not attempt to read the device; instead it will display **USB device unrecognised**. You can now reformat the device using the **FORMAT A:** command.

Part H – *DT80* Front Panel

The *DT80* front panel user interface comprises:

- a 2 line by 16 character back-lit liquid crystal display (not DT81)
- 6 keys (not DT81)
- 4 status indicator lights (3 for DT80 Series 1)

The display provides information about data logger status, channel data, alarms and store operation. In addition the display will indicate conditions that require attention and USB memory device status.

The *DT80* from cannot be programmed from the front panel. However, pre-defined commands can be issued by selecting from the function list via the front panel.

Figure 21 DT80 Front Panel

Display

(Not applicable to DT81)

The display normally shows the current value for each channel and alarm in the current job. Each channel or alarm is shown one at a time. The **Up** and **Down** directional keys on the front panel are used to scroll through the available channels, as well as various status screens. The channels and alarms are arranged in the same order that they are defined in for the current job.

Displaying Channels and Alarms

When channel data is displayed, the top line of the display shows the channel identification. The default is the channel number and type. If channel identification text has been entered as a channel option, then the first 16 characters of that text is displayed.

The bottom line on the display shows the most recent reading as a numeric value or bar graph. If the channel or alarm has not yet been sampled, the display shows " `NotYetSet`".

When alarms are displayed the top line of the display identifies the alarm and the state of the alarm – ON or OFF. If the alarm channel definition includes identification text, then this is displayed when the alarm is not true. If the alarm contains action text, this is displayed when the alarm is true.

Example

As an example, assume that the following job has been defined:

```
BEGIN"MYJOB"
RA1M 1TK("Boiler Temp",FF0)
 2LM35
 ALARM4(3V>2000)"Over voltage"
 1CV(W)=1CV+1
 ALARM7(4TT("Oven OK")>107)"Oven Over Temp"
END
```

The following "screens" will then be available. These can be scrolled through using the **Up** and **Down** arrows on the keypad. Pressing **Down**

Display screen	Comments
DT80 V8.04 MYJOB	The default "sign-on" screen indicates the *DT80*'s firmware version number and the name of the currently loaded job (**No current job** is displayed if there isn't one)
Date: 23/10/2009 Time: 16:44:02	Current date and time (format can be changed using P31 and P39)
Battery: 90% ↓ -290mA 6.2V	Internal battery status. This shows the approximate battery charge as a percentage, a charge (↑) or discharge (↓) indicator, battery current (negative=discharging) and the battery terminal voltage. **NC** is displayed if the internal battery is not connected. This screen is not present on models with no internal battery charger, e.g. DT82E
Eth IP: Auto 192.168.11.160	Ethernet port mode (Automatic, Manual or Disabled) and current IP address
Boiler Temp 97 °C	First user channel (user defined channel name)
Channel 2LM35 17.9 °C	Second user channel (default channel name)
Alarm4 OFF 1356.3 mV	Alarm #4 state
Oven Over Temp 117.2 °C	Alarm #7 state (alarm text replaces channel name when alarm is active)

Note that channel **1CV** is not displayed because it is defined as a working **(W)** channel. Working channels are neither logged, returned nor displayed.

Bar Graph

The channel value can be shown as a bar graph instead of a numeric value by using the **BG** channel option. The **BG** option allows the values to be set that represent the left and right side of the graph scale. The channel label can be used to set the graph scale labels. For example:

Display screen	Comments
E--Fuel Level--F ▮▮▮▮▮▮▮	**4V("E--Fuel Level--F",BG10:900)** displays zero scale (no bars) if measured voltage < 10mV; displays full scale (16 bars) if voltage > 900mV

Controlling what is shown on the display

All defined channels and alarms will be shown on the display, **except for:**

- channels which specify the **ND** (no display) channel option
- working channels (**W** channel option)
- un-numbered alarms
- alarms where the channel in the alarm condition is a no-display (**ND**) or working (**W**) channel

For example:

```
4TT                          ' displayed
3CV(W)=3CV+1                 ' not displayed
ALARM1(2CV>10)"Quokka"       ' displayed
ALARM(2CV>20)"Platypus"      ' not displayed
ALARM2(2CV(ND)>30)"Echidna"  ' not displayed
```

Auto-scrolling

The *DT80* may also be configured to automatically scroll through the channel display screens. This is useful in applications where the *DT80* is mounted behind a glass panel – the display is visible but the keypad is inaccessible.

To enable auto-scroll set the following profile:

```
PROFILE DISPLAY AUTOSCROLL_INTERVAL=10S
```

which in this case will automatically switch between channel display screens every 10 seconds. If this profile is set to 0 then auto-scroll is disabled.

Pressing a key on the keypad while auto-scroll is active will temporarily suspend auto-scroll and allow you to manually navigate through the screens. By default, auto-scroll will resume (if it is enabled) 30 seconds after the last key press. This time can be changed using:

```
PROFILE DISPLAY AUTOSCROLL_DELAY=1M
```

which in this case will wait one minute before resuming auto-scroll.

Auto-acknowledge

In applications where the keypad is inaccessible, the following profile can be set to automatically aclnowledge (clear) any pop-up messages after a period of time:

```
PROFILE DISPLAY AUTOACK_DELAY=1M
```

Set to 0 to disable this feature.

Pop-up Messages

The display may also show temporary status screens, such as.

Display screen	Comments
Reading USB device	When a USB device is inserted the *DT80* needs to read certain system information from it before it can be used.
USB device unrecognised	This indicates that the *DT80* does not recognise the device as a valid USB mass storage device.
Run ONINSERT?	This is displayed briefly following insertion of a USB memory device that contains an **ONINSERT.DXC** file. Press **OK** to allow the file to execute (which is the default), or press any other key to skip execution of the file.
Processing ONINSERT.DXC	If the USB memory device contains a file called **ONINSERT.DXC** then it will be automatically loaded and run by the *DT80*
Copy→USB 1/3 ▮▮▮▮▮▮▮	This indicates progress during a **COPYD** operation where the destination is set to the USB device. The numeric counter on the top line indicates the data/alarm store being processed (store 1 of 3), while the bargraph shows unload progress for each store.

Display Backlight

The display backlight will normally only stay on for 30 seconds after the last key press. The actual period that the backlight stays on for after a key press is controlled by **P17** in seconds.

Parameter **P20** *(P200)* can be used to further control the operation of the backlight, for example setting **P20=0** will cause the backlight to be always off, while **P20=1** will leave the backlight always on (except while the logger is sleeping).

User Defined Functions

(Not applicable to DT81)

The user can define up to 10 named macros called functions. These functions can be executed by the user via the LCD and keypad of the *DT80*.

Defining Functions

Functions are defined using the following profile settings, one pair for each of the 10 available functions:

PROFILE FUNCTION F1_LABEL=*label*
PROFILE FUNCTION F1_COMMAND=*command string*

These will define the label to display on the LCD (up to 16 characters), and the command string to execute when the function is selected. Substitute **F2**, **F3** etc. in the profile key names to define further functions.

Enclose *label* or *command string* in double quotes if they contain spaces or special characters.

For example:

Command	Description
PROFILE FUNCTION F1_LABEL=Start **PROFILE FUNCTION F1_COMMAND=G**	This function would display **Start** and when selected would issue the G or go command to the logger which would start all schedules
PROFILE FUNCTION F2_LABEL="Temp \176F" **PROFILE FUNCTION F2_COMMAND=REFT(S2,=5CV)**	This function would display **Temp °F** and when selected would measure the logger's internal temperature and store the scaled value to channel variable 5CV
PROFILE FUNCTION F3_LABEL=Upload **PROFILE FUNCTION F3_COMMAND="copyd start=new dest=ftp://x.com/unit42/"**	This would display **Upload** and when selected would unload new data to an FTP server
PROFILE FUNCTION F4_LABEL=Clear **PROFILE FUNCTION F4_COMMAND=1..20CV(W)=0**	This function would display **Clear** and would set channel variables 1-20 back to zero.

Selecting Functions

Pressing the **Cancel/Func** key will cause the function list to be shown on the display. One function is shown at a time, and only those functions which have a command defined are shown. The up and down direction keys can be pressed to scroll through the list of functions. Once the desired function is visible on the display it can be executed by pressing the **OK/Edit** key. If you wish to exit the function list without executing any function then press the **Cancel/Func** key to cancel the function selection process.

After selecting the function to execute, the display will indicate that the function selected has been initiated.

Default Functions

Following reset, the *DT80* automatically defines three commonly used functions:

- **Remove USB** – disables USB memory device to allow safe removal
- **Copy logged data** – unload all logged data for current job to USB memory device
- **Auto Ethernet IP** – sets Ethernet port to AUTO and forces the *DT80* to re-acquire an IP address

These can be redefined or removed if desired by changing the profile settings.

Keypad operation

(Not applicable to DT81)

Direction Keys

The up and down direction keys allow scrolling through the available channels, alarms and status screens on the display. When the function list is shown, then the up and down direction keys allows scrolling through the list of available of functions.
The left and right direction keys are not currently used.

OK (Edit) Key

The **OK/Edit** key is used to select a function to execute when the function list is displayed. The edit function will be used in a later firmware version that supports editing of values.

Cancel (Function) Key

The **Cancel/Func** key is used to enter the function list display. It can be pressed again to exit the function list without selecting a function.

Special Key Sequences

Entering Bootstrap Mode

Holding down the **OK/Edit** key during the logger reset or power-up sequence will force the logger into bootstrap mode. This would only be required if there is a corruption of the firmware in the logger.

Status Indicator Lights

Sample Indicator

The **Sample** indicator is illuminated whenever any channel in the current job is sampled. This includes all analog, digital and internal channels.

Disk Indicator

The **Disk** indicator is illuminated whenever the internal disk is reading or writing. For example, the disk indicator will illuminate when writing data to the internal data store or when unloading data from the data store.

Power Indicator (not DT80 Series 1)

This indicator flashes every 3 seconds while the logger is awake. A long "LED on" time followed by a short "LED off" time indicates that the logger is externally powered; a short "on" time followed by a long "off" time indicates battery power.

Attn Indicator

This LED is used to:

- warn that an unexpected *DT80* reset has occurred (flashing)
- warn that logging has been partially or fully suspended (flashing)
- indicate a warning state under the control of a user program (continuously on)

Unexpected Reset

A message such as the following may be displayed following *DT80* reset, in conjunction with a flashing **Attn** LED. Press any key to clear the message and the flashing LED.

Display	Comments
DT80 restarted Power loss	The *DT80* lost power, both external and the internal battery. This message may also be displayed if the hardware reset button (accessed using a paper clip) is pressed.
DT80 restarted Safe mode	A "triple-push" reset was performed (by pressing the hardware reset button three times within 10s), which temporarily restores factory settings
DT80 restarted SW exception	This indicates a possible problem with the *DT80* firmware. Contact Datataker Support if you see this message.
DT80 restarted All mem cleared	The *DT80* lost power, and all internal RAM has been cleared, probably due to the internal Lithium memory backup battery being flat. Programs and logged data will not be affected but you will need to reset the *DT80*'s time/date.

Logging Suspended

If data for one or more schedules cannot be logged for some reason then the *DT80* will continue to run the job but it will flash the **Attn** LED and display a message such as the following. Pressing a key will clear the message from the display, but the **Attn** LED will keep flashing until space is made available (e.g. by deleting data or inserting a USB device)

Display	Comments
Cannot log Data full	One or more schedules have been set to "no-overwrite" mode (**NOV** schedule option), and the allocated space is now full
Cannot log No USB device	The **"A:"** schedule option (log directly to USB device) has been specified, but no USB device is inserted.

User Control

You can also turn the **Attn** LED on or off using the **SATTN** (Set Attention) and **CATTN** (Clear Attention) commands.

Alternatively, the **1WARN** channel type (which works in the same way as a digital output channel) may be used.

For example:

```
RA1S ALARM1(3TT>500)"Meltdown"{SATTN}
```

will cause the LED to come on and stay on if the alarm is triggered, and

```
RA1S 1CV=(1CV+1)%10 IF(1CV==0){1WARN(R,200)=1}
```

will give a 200ms flash every tenth time the schedule is scanned.

Part I – Web Interface

What is the Web Interface?

The *DT80* provides an embedded **web interface** that provides simple, intuitive access to the logger's operations using a standard web browser. You can view current sensor readings, job status and access data and other files stored in the file system.

The standard web interface is built into the logger's firmware. It does not need to be installed on the logger or on your PC. Simply use your existing browser to browse to the logger's IP address and the home page will be displayed.

Note The *DT80* web interface is a predominantly **read-only** interface; that is, it is intended for monitoring a logger that has already been programmed.

dEX vs. Classic Web Interface

The *DT80* actually features two web interfaces:

- ***dEX***, also known as the **enhanced web interface**, is available on all Series 2 loggers. This uses *Adobe Flash* technology to provide a full-featured and easy to use interface.
- The **classic web interface** is available on Series 1 and Series 2 loggers. This HTML-based interface has fewer features than the enhanced interface, but it is customisable and is also more suitable for slow connections and small-screen web clients.

The following table summarises the differences between the two web interfaces:

Feature	*dEX*	Classic web interface
Display basic logger information (serial number, firmware version etc.)	yes	yes
Display schedule status (log/run status, number of logged records, etc.)	yes	yes
Display current channel values in tabular form	yes	yes
Display event logs	yes	yes
Display user manual, release notes, etc.	yes	yes
Graphically configure the logger, i.e. define schedules, channels and global settings without using the logger command language	yes	-
Display selected channels in a configurable "mimic" displays, including trend charts	yes	-
Unload data and save to CSV or DBD file	yes	-
Text command window (similar to *DeTransfer*)	yes	-
Display current parameter, switch and profile settings	yes	-
Display current job's program text	yes	-
Display file system free/used space breakdown	yes	-
Display TEST and SERVICEDATA command response	yes	-
User customisable branding (images, web links, help pages)	yes	-
Menu options can be selectively disabled or restricted	yes	-
Suitable for low bandwidth connection e.g. dial-up modem	-	yes
Suitable for small screen client e.g. PDA	-	yes
User customisable HTML pages	-	yes

Connecting to the Web Interface

In order to access the *DT80* web interface, a **TCP/IP** connection between the *DT80* and the PC is required. You can connect the *DT80*'s Ethernet port to a local area network, or directly to the PC using an Ethernet cross-over cable, or you can set up a serial connection to one of the *DT80*'s serial ports (USB, host or serial sensor) using the PPP protocol. See *Ethernet Communications* (P179) and *PPP Communications* (P190) for more details.

Once a TCP/IP connection has been established, all you need to do is type the *DT80*'s IP address into the address field of your browser. The web interface home page should then be displayed.

Home Page

For Series 1 loggers, when you enter the *DT80*'s IP address into your browser you will be immediately directed to the home page for the classic web interface (Series 1 loggers do not support *dEX*). See *Classic Web Interface* (P143) for more details.

If you are using a "small screen" browser e.g. *Internet Explorer Mobile*, you will also be directed to the classic web interface.

For Series 2 loggers, you have the choice of running either *dEX* or the classic interface. The first screen you will see after

browsing to the *DT80*'s IP address is the **Logger Home** screen, as shown below.

Logger home - Datataker - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://10.70.1.152/
Logger home - Datataker
dEX
Logger software
dataTaker
Intelligent data logging products
Configure the logger
- Define what tasks the logger will be performing
- Activate the logger with new or altered tasks
- Back-up or restore the logger's current configuration.
Monitor the logger
- view real time data
- retrieve historical data from the logger
- inspect the logger's status
- use logger commands
Customise dEX
- change which menus are visible
- define mimic pages
- define custom help pages
High speed connection
Low speed connection
Copyright © 2007-10 Thermo Fisher Scientific Australia Pty Ltd.
Done

Figure 22: ***Logger home*** *page*

The **Logger home** page provides four options, which are organised into two tabs. With the **High speed connection** tab selected, you can:

- click **Configure the logger** to launch the *dEX* configuration builder. This allows you to configure the *DT80* using a graphical interface, rather than the logger's command language.
- click **Monitor the logger** to launch the *dEX* web interface, which allows you to monitor the current state of the *DT80,* unload data and use the command interface.
- click **Customise dEX** to launch an application which allows you to customise or restrict parts of the web interface. See *Customising the Web Interface* (P139). Note that this option will not be present if the web interface configuration tool has been deleted from the logger by an administrator.

To launch the classic web interface, select the **Low speed connection** tab, then click **Launch web interface**.

Once the desired interface (*dEX* or classic) starts up, you may wish to bookmark its home page so that in the future you can go straight to it, bypassing the **Logger home** screen. See also *Preventing Configuration Changes* (P142).

When configuring the logger, it is often convenient to have the *dEX* configuration builder running in one browser tab, and the *dEX* web interface running in another. You can then easily switch between them without having to return to the Logger Home page.

Starting *dEX*

The *dEX* Configuration Builder and the *dEX* web interface are *Adobe Flash* applications. When you select either of these options on the **Logger home** screen, the following sequence of events takes place:

1. A check is made to see if the browser contains the required *Adobe Flash* plug-in. This plug-in is a software component produced by *Adobe Systems Inc.* which allows the web browser to run *Flash* applications such as the *DT80* web interface. The plug-in is also sometimes referred to as the "Flash Player". The Flash Player only needs to be installed once, so it is likely that your computer will already have it installed.
2. If the Flash Player is not already installed, or it is older than Version 10.0, then the browser will automatically attempt to download the required plug-in from the Internet and install it. The exact sequence of events will vary from browser to browser. You may receive various security alerts during this process which you will need to approve in order for the installation to complete. You may also require administrative rights for your computer; check with your IT department.
3. The selected *dEX* application will now be automatically downloaded from the logger onto your computer. The size of this file is approximately 1-2Mbyte, so this will take a few seconds over an Ethernet connection and considerably longer over a modem link. During this time a progress bar will be displayed.

4. The Flash Player will then launch the *dEX* application and the configuration builder or web interface main screen will appear in the web browser.

Note If your computer does not have the Flash Player installed, and does not have an Internet connection, then you will need to obtain and install the Flash Player manually. Using a computer which does have Internet access you can download the Flash Player package from www.adobe.com**,** transfer the installation file onto your computer and then launch it to install Flash Player.

Note If you press the **Refresh** or **Reload** button on your browser then the above process will be repeated. That is, the application will be re-downloaded and will then restart at the **Welcome** page. Most screens within the web interface application include an **Update** button – use this button (not the browser **Refresh** button) to update displayed information.

Browser Requirements

An *Adobe Flash* plug-in is available for most popular web browsers, including:

- *Microsoft Internet Explorer* Version 7 or later
- *Mozilla Firefox*
- *Apple Safari*
- *Google Chrome*

Once the plug-in is installed (which, as described above, is normally an automatic process), any of these browsers can be used to access the *DT80* Web Interface.

Note that JavaScript needs to be enabled in the browser options (this is normally the default).

dEX Configuration Builder

Using the Configuration Builder

The *dEX* configuration builder is used to graphically define the *DT80* **configuration**. You can define schedules, channels and global settings, then load the configuration onto the logger and start it running.

The following screenshot shows the general configuration builder screen layout:

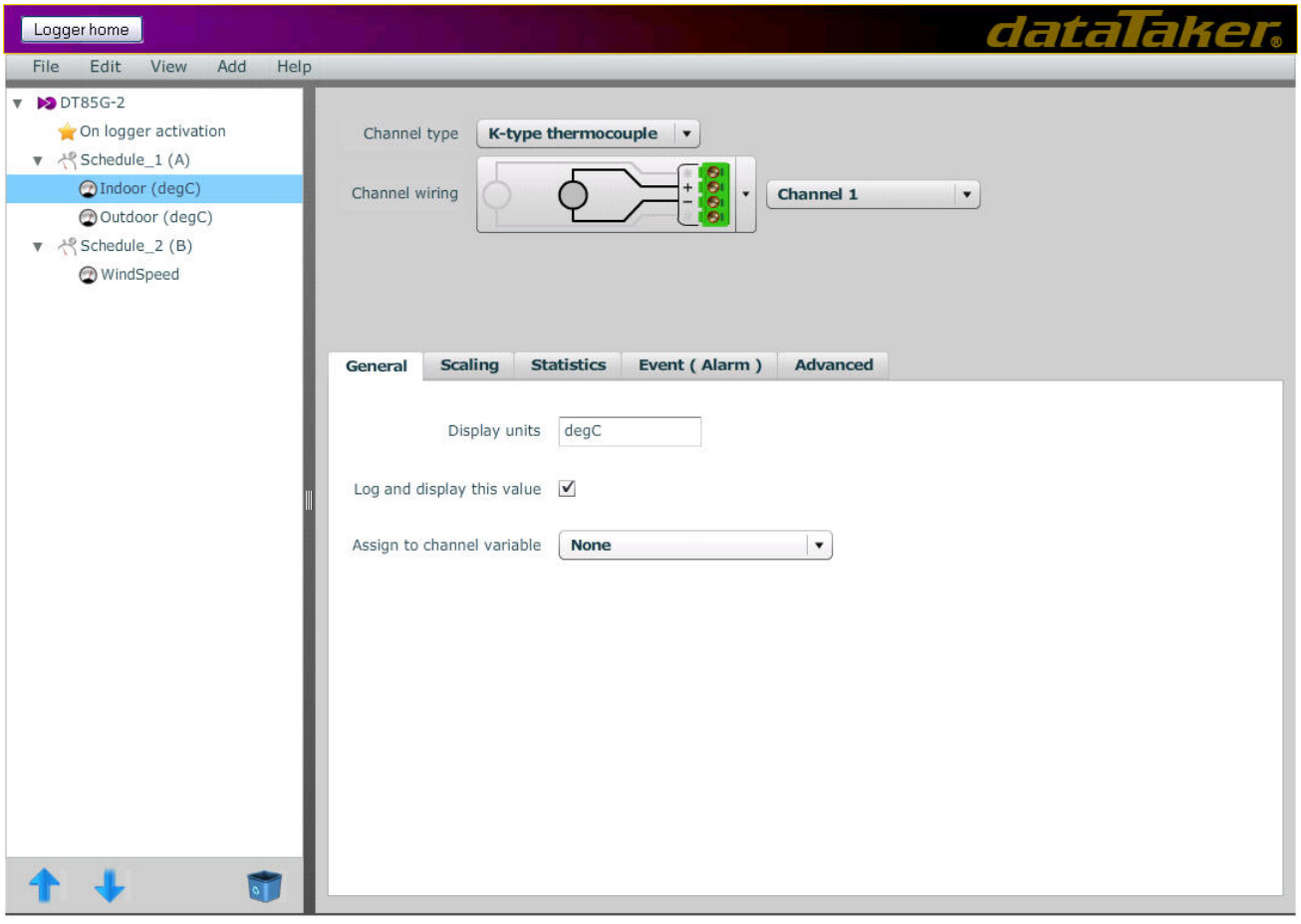


Figure 23: Typical configuration builder display

Tree View

The area on the left of the screen shows a **tree view** of the current configuration. As configuration elements (channels and schedules) are defined, entries are added to the tree view. This part of the interface thus gives an overview of the configuration, showing which channels belong to which schedules.

The tree contains three "levels", with each level's entries indented further to the right.

- At the top level there is a single entry for the logger as a whole. This entry represents the logger's global settings, such as profile settings and statistical schedule rate.
- Beneath that are the schedules. In the screenshot three schedules have been defined: the built-in **On logger activation** entry represents the immediate schedule, and is followed by two user schedules, A and B (a.k.a "Schedule_1" and "Schedule_2").
- Finally, at the third level are the channels: in this case, "Indoor", "Outdoor" and "WindSpeed".

If you highlight an entry in the tree, its details will be displayed in the large **properties pane** area which occupies most of the screen area. The border between the tree view and the properties pane can be dragged left or right to adjust the width of these two areas.

If you double click on a tree entry, its name will become editable. This allows you to rename an existing schedule or channel.

At the bottom of the tree view area are three buttons. The arrows are used to re-order items in the tree by moving the highlighted entry up or down. The Recycle Bin button will delete the highlighted entry.

Finally, the small triangles next to the logger and schedule tree view entries can be used to hide/unhide all of their constituent entries, which can reduce clutter when you are working on a large configuration.

Properties Pane

The large **properties pane** on the right hand side is used to display all of the detailed settings for the selected tree view item.

The layout of this area varies depending on the type of entry selected on the tree – logger, schedule or channel:

- If the Logger tree entry is selected, the properties pane shows some basic details of the logger, such as the model and the number of CEMs connected. This is also the place to set any of the *DT80*'s profile settings.
- If a schedule tree entry is selected then details of the schedule's trigger and storage options are shown.
- If a channel entry is selected (as is the case on the screenshot) then in most cases the top part of the properties pane will show the selected wiring configuration and channel number, while the lower part will feature a number of tabs containing detailed settings.

Menu

The **menu** bar across the top works in the same way as the menu bar in any other window-based application. Note that many of the menus have cascading sub-menus, as shown in the screenshot.

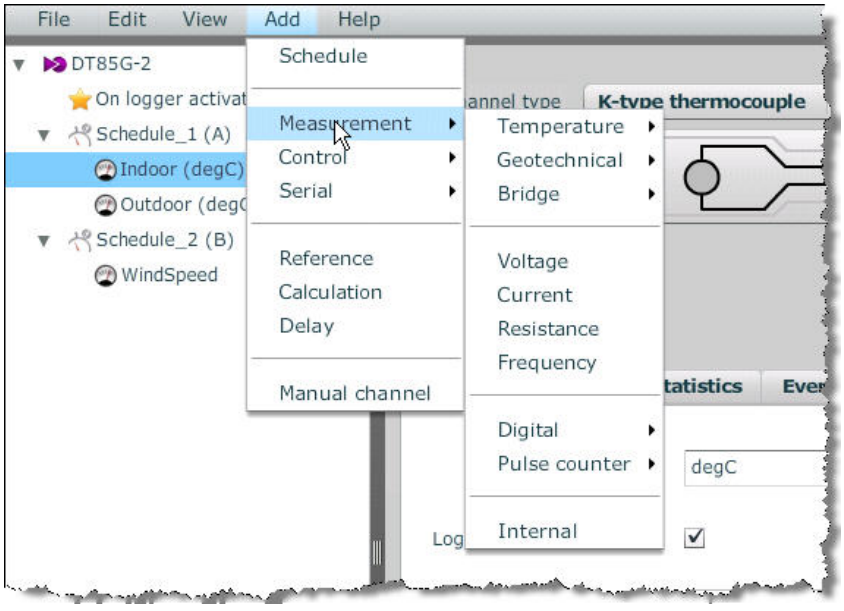


Figure 24: Typical configuration builder menu

Five menus are provided:

- The **File** menu is used to clear the current configuration or load an existing configuration, which may be either the logger's current configuration or a locally saved file. This menu also allows you to save a completed configuration to the logger, which will also "activate" the configuration, i.e. it will start running.
- The **Edit** menu simply duplicates the functions of the tree view buttons.
- The **View** menu allows you to view the logger program generated from your current settings.

- The **Add** menu is used to define new tree entries – schedules and channels.
- Finally, the **Help** menu identifies the version of the configuration builder. It also provides links to various useful files on the *DT80*, including the user manual and firmware release notes.

Banner Area

The banner area along the top of the screen contains:

- a **Logger Home** button, which returns you to the **Logger Home** page
- the *dataTaker* logo on the right hand side will jump to the dataTaker website, **www.datataker.com**

Note Navigating away from the configuration builder using the **Logger Home** button, or the dataTaker web link, or pressing the browser Refresh button will all cause any unsaved configuration entries to be lost. Be sure to save your work (using **File / Save to disc...**) before leaving the configuration builder.

It is often convenient to have the configuration builder running in one browser tab, and the *dEX* web interface running in another. You can then easily switch between them without having to return to the Logger Home page.

Defining Schedules

When the configuration builder starts up, two pre-defined schedules are shown: the immediate schedule (**On logger activation**) and one user schedule (A).

If you click on schedule A's entry in the tree view its details will be displayed in the properties pane.

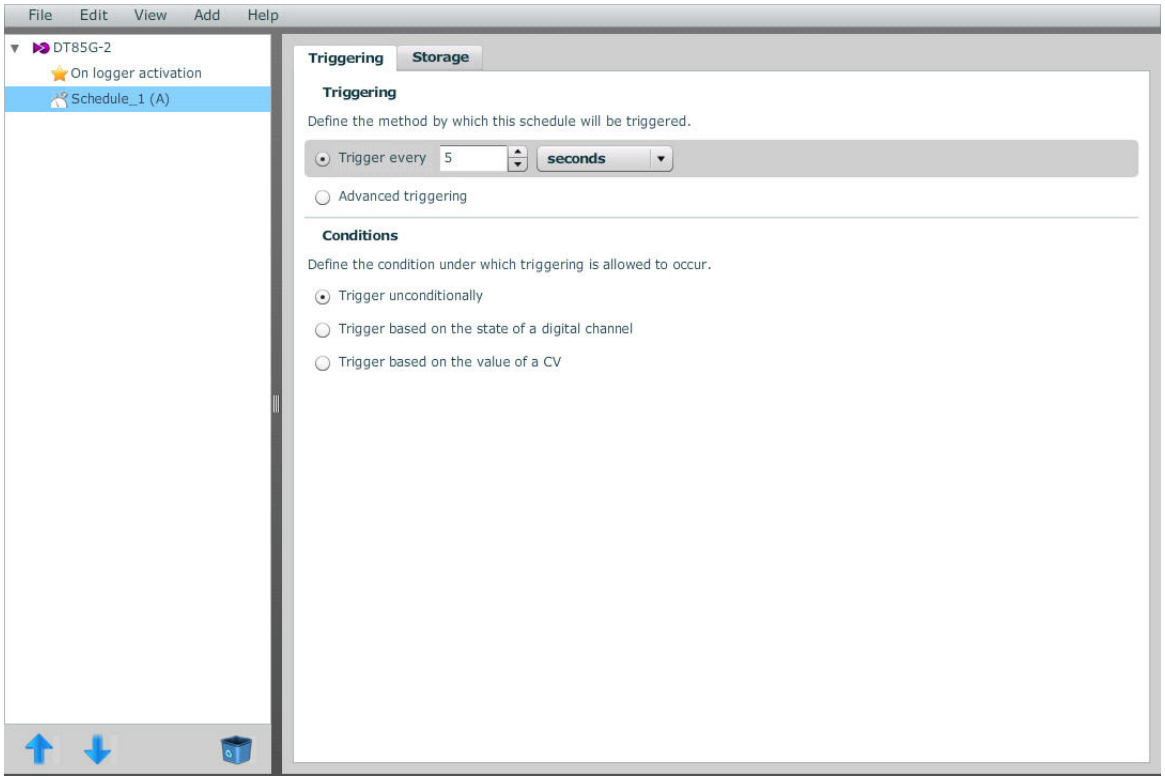


Figure 25: Schedule configuration

By default, the configuration builder sets a new schedule to a 5 second trigger. To change this time, simply set the **Trigger Every** control. To define other types of schedule trigger (e.g. event triggered, manual trigger), click on **Advanced Triggering**, which will cause more controls to appear.

The **Conditions** area is used to define the schedule "while" condition (see *Trigger While* (P50)) – where, for example, a schedule will only trigger while a certain digital input is active. By default, there is no while condition.

To set the schedule storage parameters, click on the **Storage** tab. This allows you to define various schedule options such as store file size and whether you want old data to be overwritten by new.

Note that the **On logger activation** (immediate) schedule does not have a trigger or any storage options, so if you select it the properties pane will be blank.

To add a new schedule, select the **Add** menu, then **Schedule**. This will add a new entry to the tree view, and display it with the name editable. Enter a name for the schedule then click the green tick.

To change the priority order of schedules, select a schedule on the tree and use the up/down arrow buttons at the bottom of the tree view to move it up or down. Note that if the schedule order is changed then the schedule identifier (A, B etc.) will change but the schedule name will remain the same. The topmost user schedule in the tree is always schedule A.

Defining Channels

In the configuration builder, the *DT80*'s channel types are categorised as follows:

- **Measurement** channels include all analog, digital and internal channel types
- **Control** channels are digital outputs
- **Serial** channels currently include the **SDI12** channel type only
- **Reference**, **Calculation** and **Delay** channels refer to the **&***chan*, **CALC** and **DELAY** channels
- **Manual** channels allow entry of a channel definition using the *DT80* command language. Use this for any channel types not directly supported by the configuration builder.

To add a new channel:

1. In the tree view, select the schedule to contain the new channel, or select any existing channel within that schedule.
2. Select the **Add** menu, then find the required channel type.
3. An entry for the channel will be added to the tree. Enter a name for the channel, and click the green tick (or press Enter).
4. For most measurement channels, you now need to select a wiring diagram from the available choices on the properties pane, and select the channel number.
5. If required, the other channel options in the tabs in the lower part of the properties pane can now be set.

Note All channel names in a configuration must be unique.

Measurement and Serial Channels

All measurement and serial channel types have a similar properties pane layout, as shown in *Figure 23.*

The control at the top of the screen specifies the specific channel type. In some cases this control is used to further refine the channel type selected in the **Add** menu, in other cases it is a fixed value. In the example shown, **Thermocouple** was selected in the **Add** menu, then **K-type thermocouple** was selected on this control.

Next comes the wiring configuration and channel number controls. These must both be set in order for the configuration builder to generate a correct logger program.

The remainder of the options are presented in five tabs in the lower part of the properties pane. These all have default settings; however you should check that these defaults match your requirements.

General Settings

The most important setting on this tab is the **Log and display this value** checkbox. For intermediate calculation channels (working channels) this should normally be cleared to avoid cluttering the logged data with intermediate channels.

Note that the configuration builder does not support individual control of channel value display, logging and return (**ND**, **NL** and **NR** channel options).

This tab also sets the units string that will be included in CSV data headings and shown on the display (assuming that the "log and display" checkbox is ticked)

You can also assign the measured value to a channel variable. You may want to do this if the value is to be made available to a Modbus client system, for example. If you want to use the value in a calculation, then it is easier to just use a direct **reference** to the channel in the calculation; there is no need to assign it to a CV.

Some channel types may include other controls on this tab. For example, for an SDI-12 channel the device and register addresses are specified here.

Scaling

The **Scaling** tab is where you define either a simple scaling factor (channel factor), or a span or polynomial. Selecting "Spans and Polynomials" will bring up a list of defined spans and polynomials on the left hand side. Clicking on an entry will show its details in the area on the right.

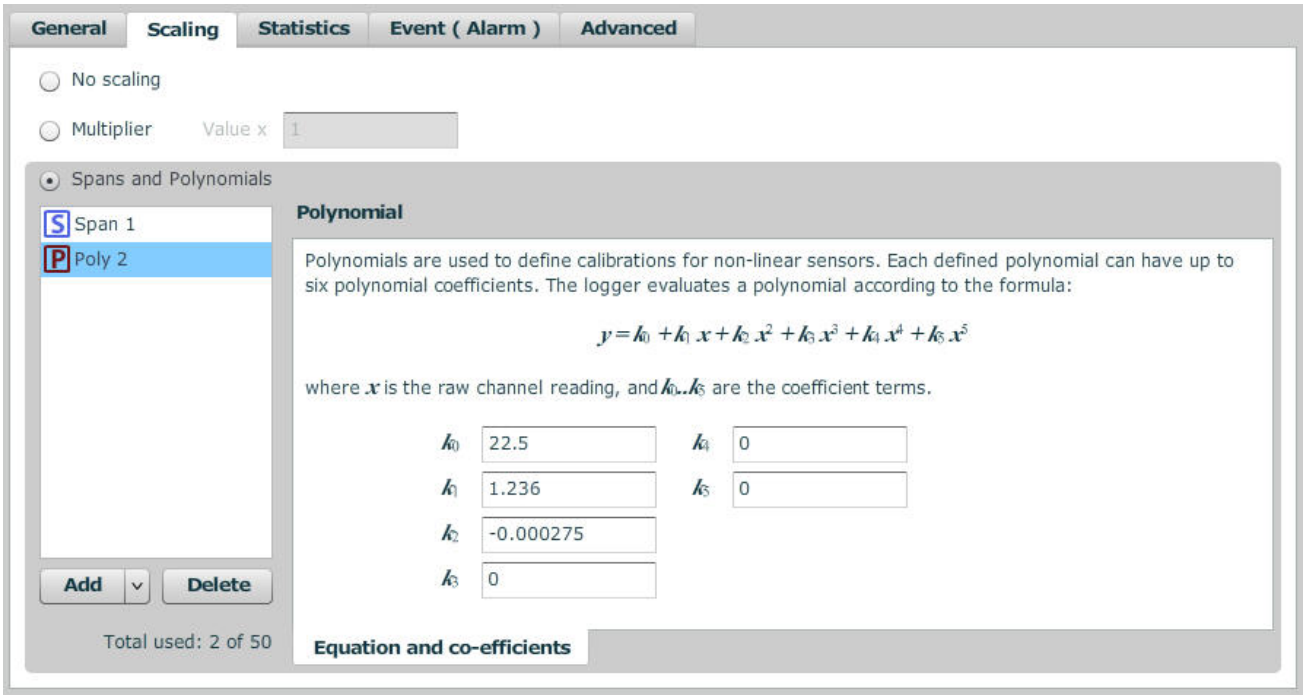

General
Scaling
Statistics
Event (Alarm)
Advanced
No scaling
Multiplier
Value x
1
Spans and Polynomials
Span 1
Poly 2
Add
Delete
Total used: 2 of 50
Polynomial
Polynomials are used to define calibrations for non-linear sensors. Each defined polynomial can have up to six polynomial coefficients. The logger evaluates a polynomial according to the formula:
$y = k_0 + k_1 x + k_2 x^2 + k_3 x^3 + k_4 x^4 + k_5 x^5$
where x is the raw channel reading, and $k_0..k_5$ are the coefficient terms.
k_0 22.5
k_1 1.236
k_2 -0.000275
k_3 0
k_4 0
k_5 0
Equation and co-efficients

Figure 26: Defining a polynomial

Initially, no spans or polynomials will be defined. To add one, click the **Add** button, select **Span** or **Polynomial**, then enter the required coefficients. In the above screen shot, the following polynomial has been defined:

$22.5 + 1.236x - 0.000275x^2$

Note that span and polynomial definitions are shared between channels. If you now define a new channel, all previously entered spans and polynomials will be available for selection. This means that if you select an already defined polynomial and then edit it (change the coefficient values) then you may be affecting other channels. A warning is displayed when an existing span/polynomial is selected to remind you of this.

Statistics

The **Statistics** tab is used to define additional statistical report values for the selected channel.

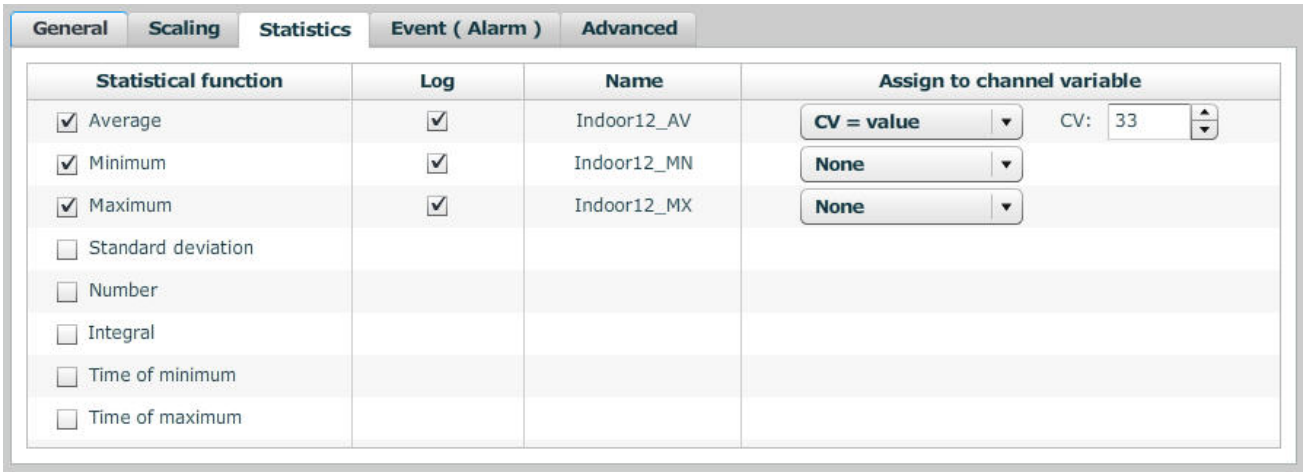


Figure 27: Defining additional statistical report values

For each row that is ticked, an additional measurement value will be calculated and reported. So in the above example a total of four values will be logged: the original measurement, plus the average, minimum and maximum values calculated over the period since the time the enclosing schedule was executed.

If any statistical values are defined for a channel, the channel will then be sampled at the statistical schedule rate, rather than the rate of the channel's own schedule. It will, however, still be logged at its own schedule's rate.

The statistical schedule rate is a global setting, which is set by clicking on the top level "logger" entry in the tree view.

For example, if the statistical schedule rate is set to its default of 1 second, and the above channel's schedule is set to its default rate of 5 seconds, then the sensor will be sampled once per second. Every 5 seconds it will log the instantaneous value of the sensor, plus the average, minimum and maximum, calculated over the previous 5-second period.

For each selected statistical value, an automatically generated channel name is used (e.g. "Indoor12_AV**"**), which consists of the channel name plus a suffix describing the statistical operation.

You can choose not to log a calculated statistical value. For example, it may be being used as an input to a calculation channel.

Finally, each statistical value may optionally be assigned to a channel variable. You may want to do this if the value is to be made available to a Modbus client system, for example.

Event/Alarm

This tab is used to create an alarm channel. This will test the channel's measured value against a setpoint and then take some action if the condition is satisfied. Alarms are also referred to as "events" in the configuration builder.

The first step in defining an alarm is to specify the alarm condition.

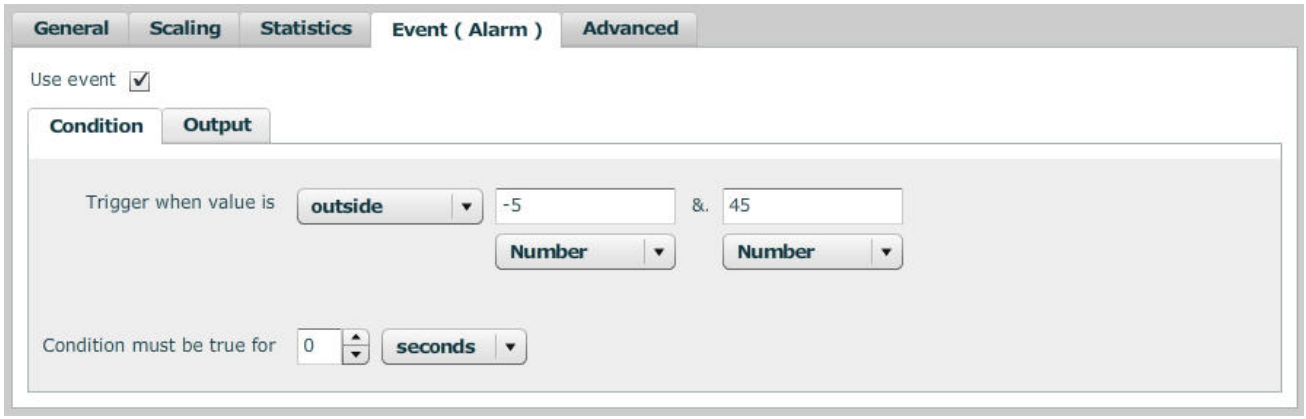


Figure 28: Defining an alarm condition

In the above example, the alarm condition will be true if the channel value is outside the range -5 to +45.

The next step is to define the actions to perform.

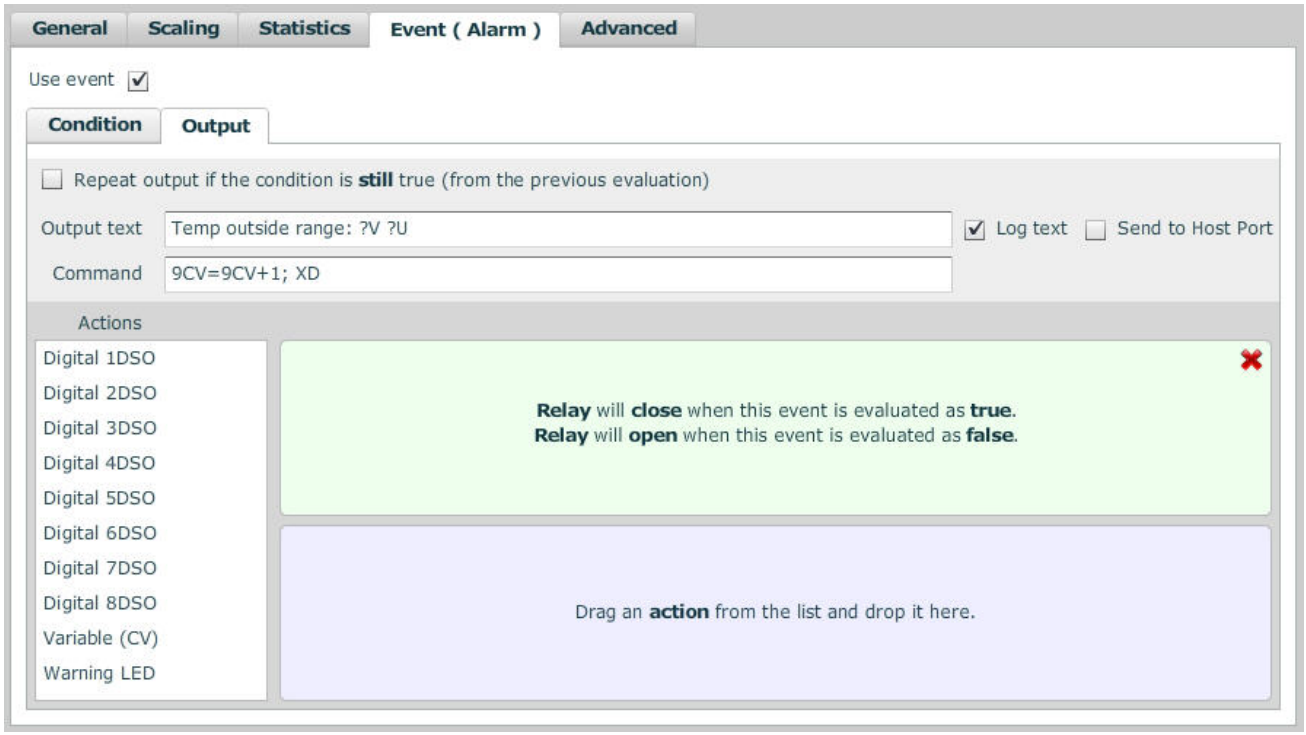


Figure 29: Defining alarm actions

The checkbox at the top specifies whether the actions should be repeated each time that the alarm condition tests true, or whether they should be performed once, when the alarm condition goes from false to true. In *DT80* parlance, the former is an **IF** channel, while the latter is an **ALARM**.

The **Output text** field specifies the alarm text, which will be logged to the schedule's alarm store when (or while) the alarm is triggered. Special "substitution characters" can be included, which will cause the *DT80* to insert certain dynamic values. In the example above, the **?V** and **?U** sequences will be replaced by the channel value and units respectively. The logged alarm string will therefore be something like:

```
Temp outside range: 49.2 degC
```

As well as being logged, the alarm text is also sent to the *DT80*'s currently active comms port. If the **Send to Host Port** option is set then it will instead be sent to the host RS232 port, regardless of which port is currently active. This is typically used for sending modem control messages.

The **Command** field specifies one or more *DT80* commands to perform when (or while) the alarm is triggered. In this case the command string is:

```
9CV=9CV+1; XD
```

which will increment channel variable 9CV, then manually trigger schedule D.

The state of the alarm (true or false) can also be mirrored on up to two digital outputs or channel variables. To enable this feature, choose one or two of the outputs in the list on the left and drag them to the two areas on the right. In the above example the **Relay contact** output has been selected, so the *DT80* relay output will now be closed whilst the alarm is active.

To remove an action, click the red cross.

Advanced

The **Advanced** tab contains various other options, which will vary according to the channel type. For example, an analog channel might include input gain lock settings, while a frequency input channel might have a sample period setting.

For most channel types, data manipulation options (e.g. rate of change) can also be selected here.

Control Channels

Control channels are outputs, so many of the options to do with sampling or processing the channel return value are not relevant. Consequently there is only one tab for these channel types.

In the configuration builder, three different digital output channel types are provided (LED driver, Relay driver and Logic state). These all translate to the logger **DSO** channel type, the only difference between them is in the displayed graphics for the wiring diagrams and controls.

A typical properties pane display for a control channel is shown below.

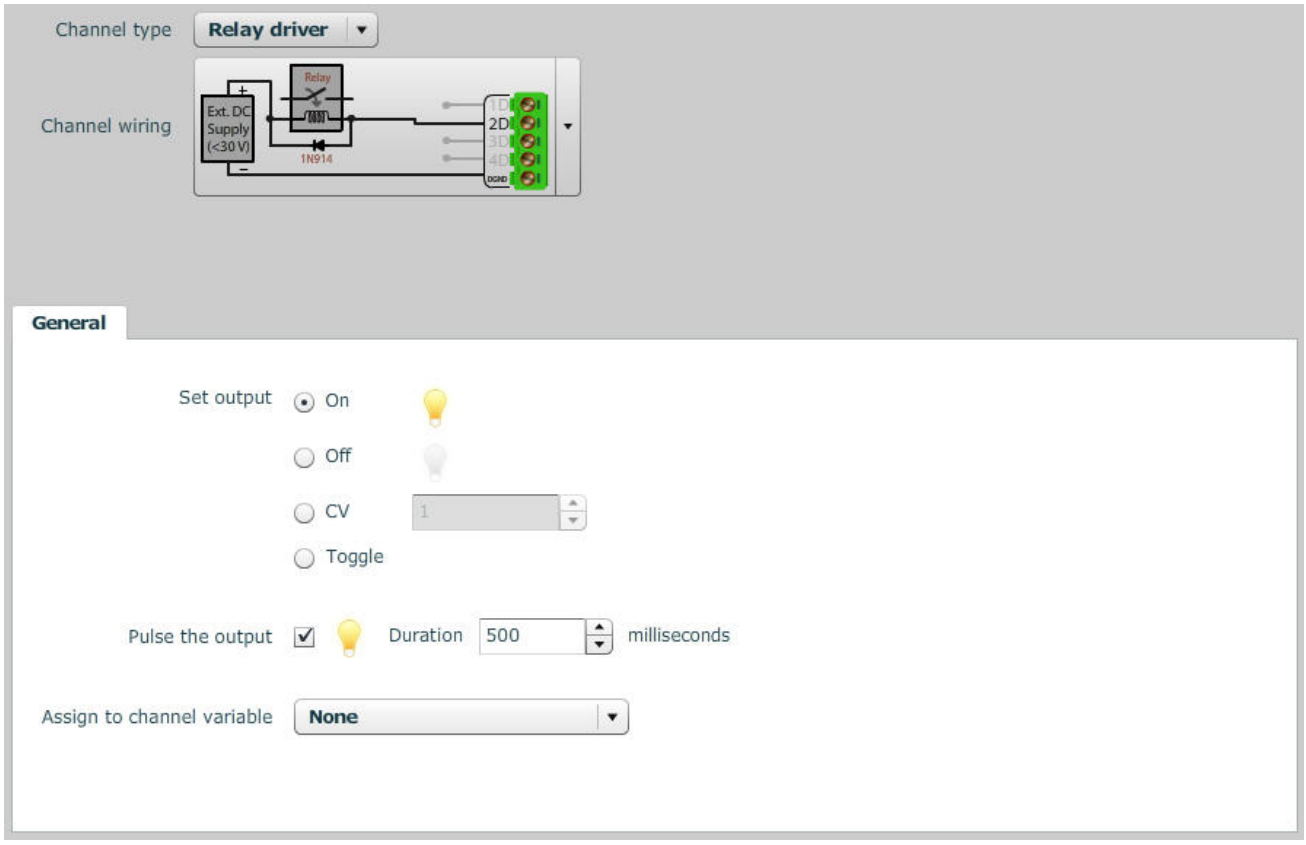


Figure 30: Defining a control channel

For digital outputs, the channel number is selected by choosing the appropriate wiring diagram, rather than setting a separate control (as is the case for analog channels).

The controls in the lower part of the properties pane select whether the control output state should be on, off, set according to a CV value (on if the CV is non-zero, off if it is zero) or inverted.

You can also specify that the output should be pulsed – that is, set to the specified state for the indicated time, then inverted. Thus in the above example the *DT80* relay will be held closed for 500ms then released.

Special Channel Types

Reference

A reference channel gets its value from another previously measured value. Thus if you add a reference channel you will be asked to select which existing channel you wish to reference.

Other than that, a reference channel is configured in a similar way to any other measurement channel, i.e. the same five tabs of options are displayed.

References are useful in alarms. You can define multiple alarm channels, all of which are testing a reference to a single measurement against different setpoints.

Note Reference channels cannot be added to the On Logger Activation (immediate) schedule, and channels in the On Logger Activation schedule cannot themselves be referenced.

Calculation

A calculation channel gets its value from an mathematical expression, which may include references to other measurement channels. The result of the calculation can be logged, have statistics applied to it, and so on – the same as any other measurement channel.

The configuration builder provides an "expression builder" to make it easier to enter a valid expression. This will appear when you click inside the **Calculation** field.

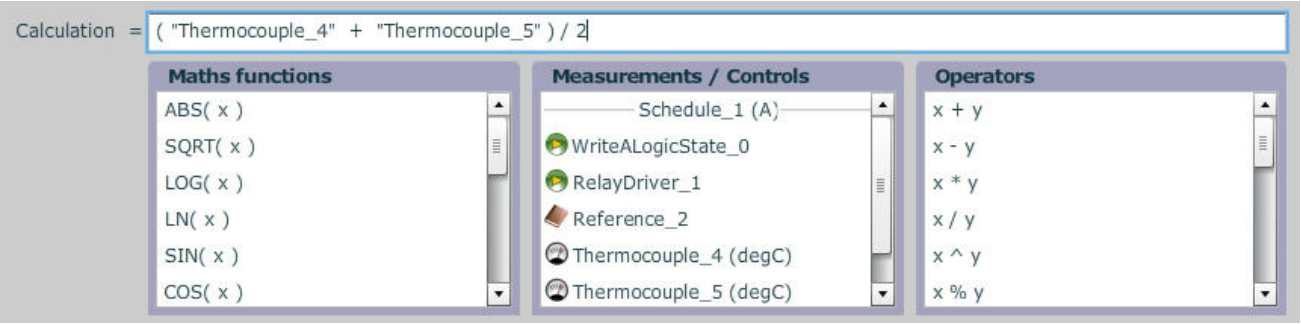


Figure 31: Defining a calculation

The three boxes below the calculation entry field list the available maths functions, operators and previously defined channels that can be referenced. Clicking on any of the items in these boxes will insert it into the calculation entry field. You can also edit the calculation field manually.

In the above example, the calculation channel is working out the mean of two separate thermocouple readings.

Delay

The **Delay** channel inserts a fixed delay between the execution of the channels immediately above and below it in the tree view.

Manual Channel

This channel type allows you to manually define one or more channels. It is useful for situations where the configuration builder does not directly support the *DT80* channel type you wish to use – for example the generic serial channel (**SERIAL**).

Anything you type here will be copied verbatim to the generated *DT80* program – no syntax or consistency checking is performed by the configuration builder.

One substitution that will be made, however, is that any occurrences of **$name** will be replaced by the actual name of the manual channel, as shown in its tree view entry.

Global Settings

Clicking on the top entry in the tree view will display the logger's global settings.

CEMs

If your logger has CEMs connected then the **Number of CEMs** field must be set correctly, otherwise you will not be able to enter select the channel number for any CEM-connected sensors.

Note also that the configuration builder assumes that the CEMs' addresses are set sequentially starting at 1. That is, if you specify that two CEMs are connected then they must be set to addresses 1 and 2.

Statistical Schedule

The statistical schedule rate is a global logger setting. Any channels which are configured to report statistical values will be sampled at this rate, which should always be faster than the channel's schedule's trigger rate.

Profile Settings

When you start a new configuration, the displayed profile settings will be initialised by reading them from the logger. You may then change any of these settings by clicking on the appropriate item in the **Value** column, changing it then clicking anywhere else to save the changed value.

Any non-default profile settings have the value highlighted in red.

Regardless of whether you modify them or not, the displayed profile settings become part of the configuration and will be included as part of the logger program generated by the configuration builder.

Note that changing certain profile settings (e.g. Ethernet IP address) may result in the configuration builder not being able to communicate with the *DT80*. A warning will be displayed in these cases.

Managing Configurations

The **File** menu is where you manage the logger configurations that you create with the configuration builder.

Backing up Configurations

You can save the configuration that you are working on to your computer using the **Save to disc...** option on the **File** menu.

By default, *dEX* configuration files have a **.dex** file extension.

Likewise, you can open a saved configuration by selecting **Open from disc...**

Activating a Configuration

Once your configuration is complete, you can save it to the logger and it will then start running. The process is as follows.

1. Select **Save to logger** on the **File** menu.
2. The configuration builder will first check whether there is an existing job on the logger which has the same name as that used by the configuration builder (which is **CONFIG**), and which has existing logged data. If so, a warning will be displayed, indicating that any logged data for the existing job is about to be deleted. If you want to keep the data from the existing job then click **Cancel**, other wise click **Continue** and it will be deleted.
3. The current logger configuration will then be reset so any currently running job will be stopped. If the logger is nearby you will hear the relays click as it performs the normal re-calibration that occurs whenever a soft reset is performed.
4. The new configuration will now be upload onto the *DT80*. This may take 30 seconds or more.
5. If all goes well the new configuration will start running immediately. If the *DT80* detects an error in the configuration then the error message generated by the *DT80* will be displayed – in this case the logger will now have no current job.
6. Once the configuration has been activated successfully, you can click the **Logger Home** button and switch over the *dEX* web interface, which will allow you to monitor the data being collected by your new configuration.

Note If there are any channels which do not have a wiring or reference source selected then you will be prompted to complete the definition of these channels before activating the configuration.

dEX Web Interface

Using the Web Interface

The following screenshot shows the general web interface screen layout:

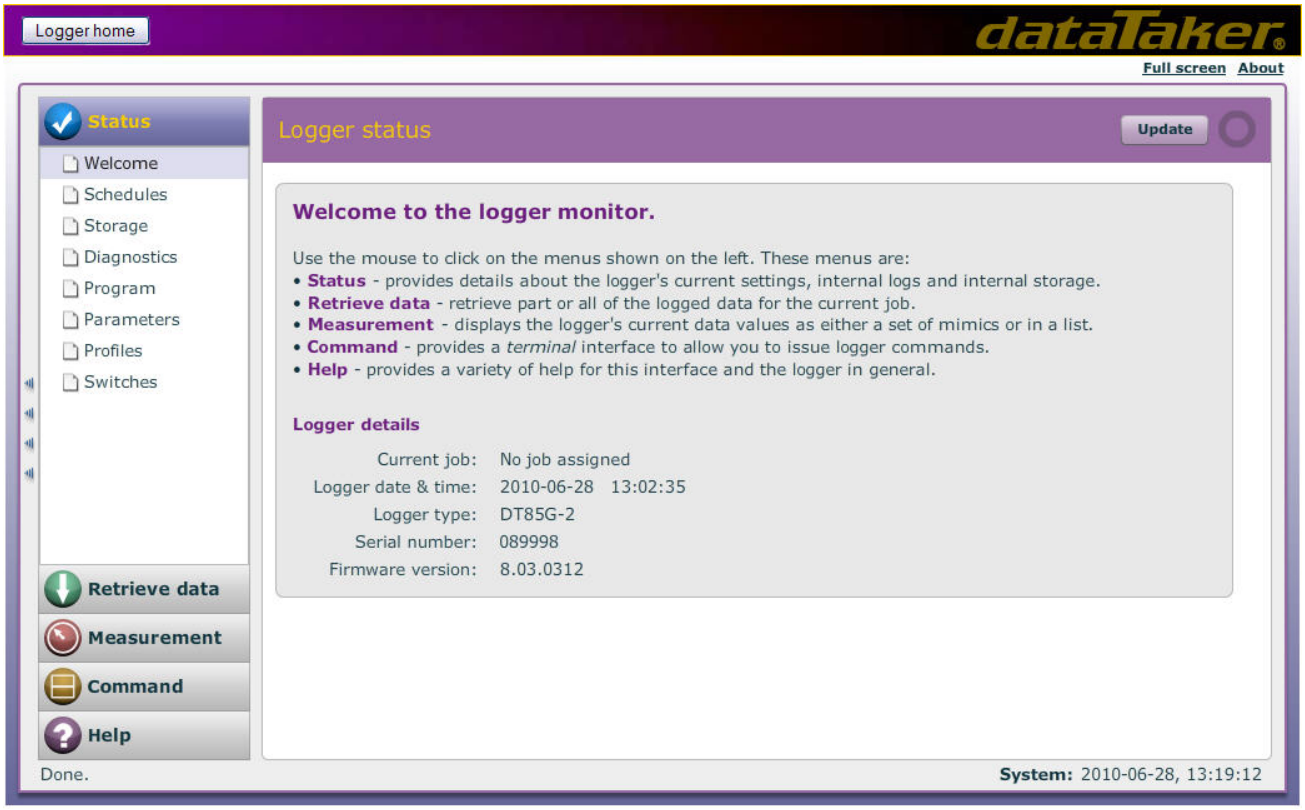

Logger home
dataTaker
Full screen
About
Status
Welcome
Schedules
Storage
Diagnostics
Program
Parameters
Profiles
Switches
Retrieve data
Measurement
Command
Help
Logger status
Update
Welcome to the logger monitor.
Use the mouse to click on the menus shown on the left. These menus are:
• Status - provides details about the logger's current settings, internal logs and internal storage.
• Retrieve data - retrieve part or all of the logged data for the current job.
• Measurement - displays the logger's current data values as either a set of mimics or in a list.
• Command - provides a terminal interface to allow you to issue logger commands.
• Help - provides a variety of help for this interface and the logger in general.
Logger details
Current job: No job assigned
Logger date & time: 2010-06-28 13:02:35
Logger type: DT85G-2
Serial number: 089998
Firmware version: 8.03.0312
Done.
System: 2010-06-28, 13:19:12

Figure 32: Welcome Screen

The *DT80* web interface comprises the following main elements:

- The large **properties pane** on the right hand side is used to display various "screens" of information. Its contents will change depending on which screen you select.
- The menus on the left hand side are used to select which screen to display. There are five menus: **Status**, **Retrieve Data**, **Measurement**, **Command**, and **Help**. Clicking on a menu button causes its list of menu items (screens) to be revealed, and the most recently selected screen will be displayed in the properties pane.

  In the above screenshot, the **Status** menu is selected. This menu has eight screens: **Welcome**, **Schedules**, **Storage**,

Diagnostics, **Program**, **Parameters**, **Profiles** and **Switches**. The **Welcome** screen is the one that is currently displayed. If you then clicked on **Parameters**, for example, then the **Parameters** screen would be displayed in the properties pane area.

Clicking on the four small triangles at the far left will hide (or restore) the menu, to allow more space for the properties pane.

Note By using the web interface configuration tool, it is possible to disable or restrict some of the menu options. The sample displays shown in *Figure 32* and throughout this section assume that all options are available (which is the factory default).

- The purple strip above the properties pane contains the name of the selected menu (**Logger Status** in this case) and may contain controls (buttons etc.) which relate to the currently displayed screen. In this case there is one button: **Update**, which will cause the displayed information to be updated. At the right hand edge of this area is the circular **activity indicator**. This symbol will be animated while the web interface is actively communicating with the logger.
- The banner area along the top of the screen contains four controls: Firstly, the **Logger home** button provides a link back to the Logger Home page (*Figure 22*). Secondly, the ***dataTaker*** logo is a link to the Datataker website (www.datataker.com). Thirdly, there is a **Full Screen** link in the top right corner. This link will display the web interface so it covers the entire screen. All browser controls will be hidden, as will the Windows task bar and desktop. To exit this mode press Esc or click the **Exit Full Screen** link. Note that all keyboard input, other than the Esc key (and certain Windows keystrokes e.g. Alt-Tab), is disabled while in full screen mode. Finally, there is an **About** link, which displays the version number of the web interface.

  Note By using the web interface configuration tool, it is possible to customise the banner area to show different logos and web links.
- Along the bottom of the screen is the **status bar**. This displays the current time and date according to the PC's clock. Other status or error messages may also be displayed here.

If the browser window is resized then all elements of the *DT80* web interface will resize appropriately. If the browser window is too small, however, then scroll bars will appear.

Many of the controls and other screen elements in the *DT80* web interface include **tool tips**. If you move the cursor over the item and hold it there, a small yellow box will appear containing a brief description of the item.

Status Screens

The **Status** menu allows you to select one of eight different screens, each showing useful information about the current status of the *DT80*.

Welcome Screen

The **Welcome** screen, as shown in *Figure 32,* is the first screen displayed when the web interface is started. It includes the following basic information about the connected logger:

- name of the currently loaded job, if any
- current date and time, according to the *DT80*'s real-time clock. Press **Update** to update the display.
- the logger product type, including model number and series (e.g. **DT80-2** for a DT80 Series 2)
- the logger serial number
- the version number of the logger's firmware

Schedules Screen

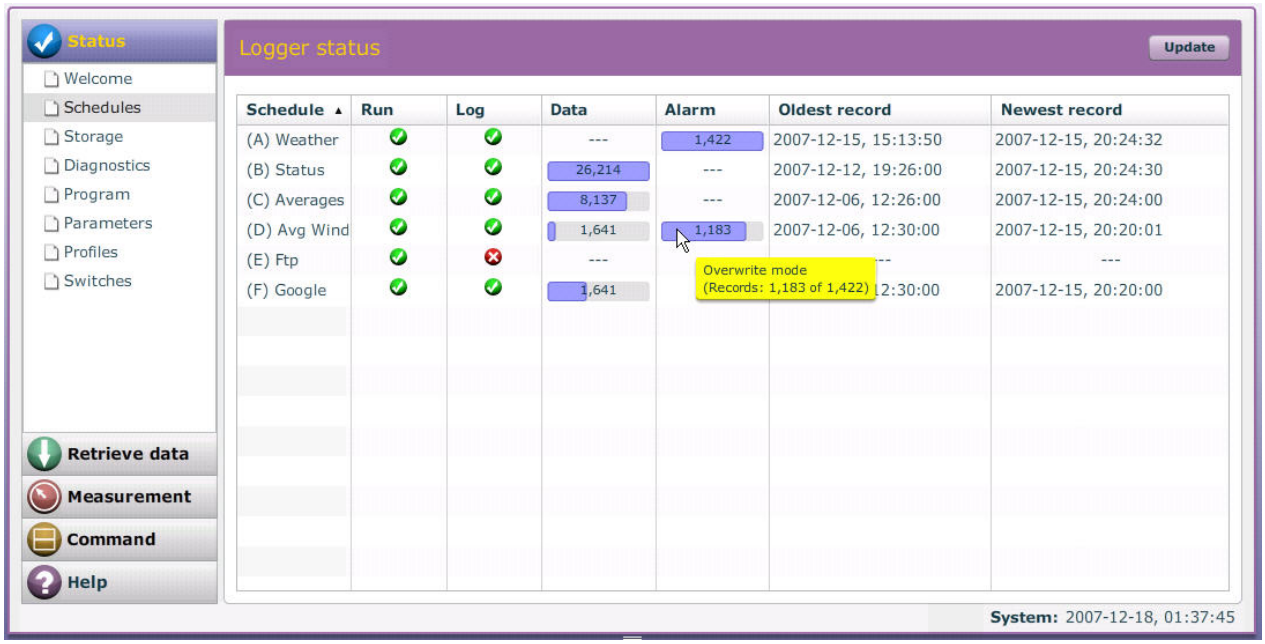


Figure 33: Schedules Screen

The **Schedules** screen shows the status of each of the schedules in the current job.

The schedules are presented in tabular form, one row per defined schedule. For each schedule the following information is displayed:

- schedule ID (e.g. **A**) and user-defined name, if any
- whether the schedule is running or halted (in the above example all six schedules are running)
- whether logging is enabled for the schedule (in this case logging is enabled for all schedules except schedule E)
- the number of logged data and alarm records. The bar graphs give an indication of the percentage of the allocated storefile space that contains data. For schedules operating in overwrite mode (which is the default), the bar graph is shown in blue. For schedules in non-overwrite mode (e.g. `RA(DATA:5H:NOV)1S`), the bargraph is shown in red if the storefile is greater than 80% full, otherwise green.
- the timestamp of the oldest logged record (data or alarm)
- the timestamp of the newest logged record (data or alarm)

Press **Update** to update the displayed details.

Click on a column heading to re-sort the table based on the data in that column. The small triangle shows which column is the current sort key.

Note also the yellow tool tip in the above screen shot, which pops up if you move the mouse cursor over the bar graphs. This shows the storefile mode (overwrite/non-overwrite), the number of logged records and the size in records of the store.

Storage Screen

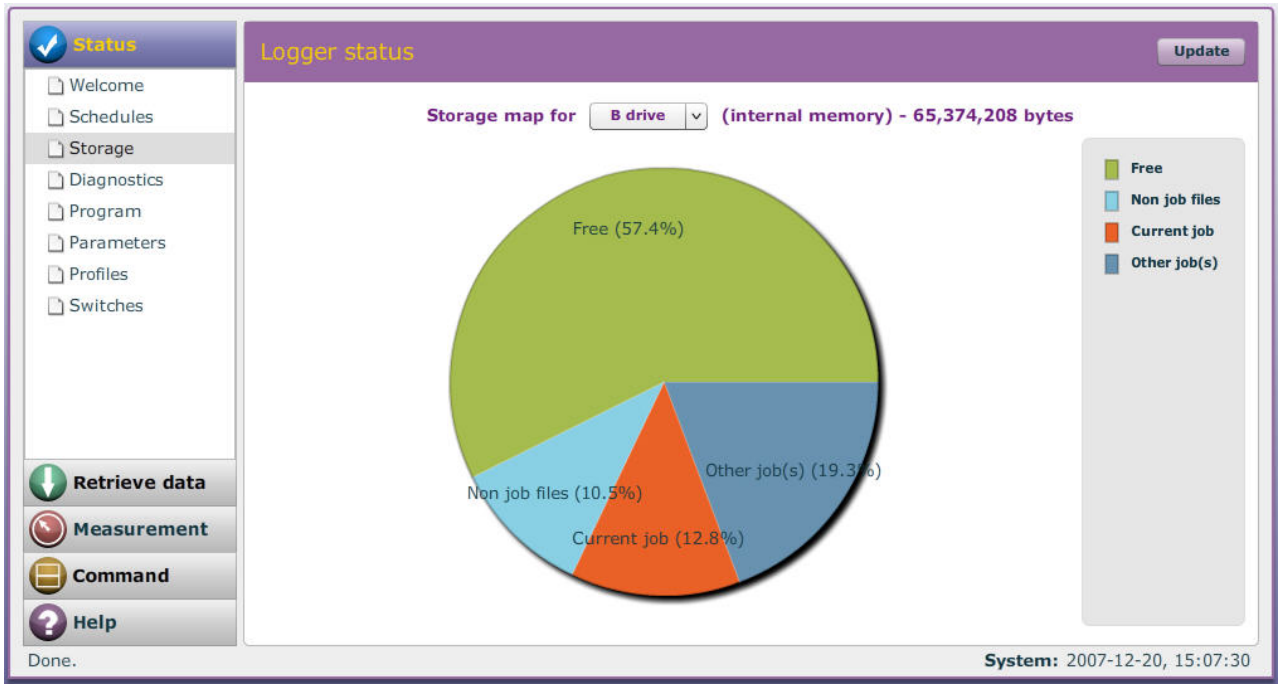


Figure 34: Storage Screen, showing details for the internal file system (B:)

The **Storage** screen provides an overview of the amount of space used and available on the *DT80*'s internal file system, or on a connected USB memory device.

Select the drive to display (B: drive – internal, or A: drive – USB device) using the control at the top of the screen.

The displayed pie chart contains up to four segments:

- **Free** (green) – this space is unused
- **Current job** (orange) – space used by current job, including program text storage, data and alarm files, and any saved archive files. Remember that the data and alarm storefiles are pre-allocated, fixed size files, so the same amount of space will be used regardless of the actual number of data points or alarms that have been logged (see *How Data and Alarms are Stored* (P86)). If there is no current job loaded then this segment will not be present.
- **Other job(s)** (dark blue) – space used by other jobs which have previously been defined but which are not currently active. If these jobs and their logged data are no longer required then this space can be recovered using the **DELJOB** command (see *Deleting Jobs* (P58)).
- **Non job files** (light blue) – this includes all other files stored on the drive, such as the web interface, user manual, event log, and so on.

The actual space used (in bytes) for each segment can be displayed by holding the mouse cursor over the legend on the right hand side of the screen.

For the USB drive (A:) only two segments are shown: **Free** and **Used**.

Diagnostics Screen

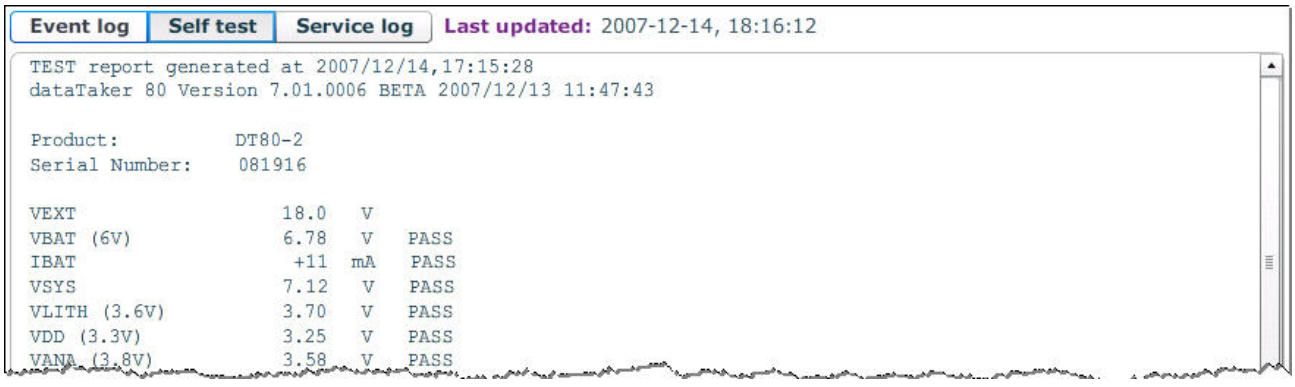


Figure 35: Diagnostics Screen, showing Self Test output

The **Diagnostics** screen provides functions which may be helpful when diagnosing a problem with the *DT80*. You can:

- display the event log, which records events such as resets and power failures (*Event Logs* (P213))
- execute a self test, which verifies correct hardware operation (*TEST Command* (P212))

- generate a full service report. This includes the above items, plus several other details regarding the state of the logger (*SERVICEDATA Command* (P214)). The report also contains details relating to the web client (i.e. your PC and browser).

To perform the desired function, press the appropriate button. If this is the first time you have selected the function then it will be performed immediately and after a short pause the data will appear. If you have previously selected the function then the previously collected data will be displayed; press **Update** if desired to repeat the operation.

Program Screen

The **Program** screen simply displays a listing of the program text for the current job, similar to the **SHOWPROG** command.

Parameters, Profiles and Switches Screens

These three screens list the current settings for the three different groups of *DT80* configuration settings, namely:

- numbered **parameters** (e.g. P11, P15 etc.), each of which has a numeric value (P200)
- named **profile settings**, each of which has a string value (P204)
- **switches** (e.g. /H, /R etc.), each of which is either on or off (P203)

Each screen has a similar format, showing the setting name, a brief description and the current value. For example the **Profiles** screen is shown below.

Section	Key	Description	Value
COMMAND_SERVER	PORT	Port number for the web server.	7700
ETHERNET	GATEWAY	Default LAN gateway used by the logger.	192.168.1.6
ETHERNET	IP_ADDRESS	LAN Ip address of the logger.	192.168.1.202
ETHERNET	SUBNET_MASK	LAN subnet mask for the logger.	255.255.255.0
FTP_SERVER	ALLOW_ANONYMOUS	FTP server's anonymous access granted.	YES

Figure 36: Profiles Screen

Items which have been changed from their factory default setting have their values highlighted in red. So in the above **Profiles** screenshot, the **GATEWAY** and **IP_ADDRESS** settings have been altered; the others are still on their default setting.

If you place the mouse cursor over a non-default (red) value then a tool tip will pop up showing the default value.

As with all other screens, pressing the **Update** button will update the displayed values.

Data Retrieval

Unloading Data Using the Web Interface

The **Retrieve Data** screen allows you to transfer logged data and alarms from the *DT80* to your computer. There are two variants of this screen:

- The **Basic** screen will be shown by default. You can retrieve data and/or alarms for the current job: either all logged data, or a specified time range, or just the new data (that is, data logged since you last retrieved data)
- The **Advanced** screen (see *Figure 37*) is the same, except it also shows details relating to the number of logged data/alarm records for each schedule (similar to the **Schedules** screen (P126)). You can also select the schedules for which to retrieve data.

This process is essentially the same as **unloading** the data, using the **COPYD** command (see *Retrieving Logged Data* (P90)), in that the logged data is read out of the logger's store files and saved in CSV or DBD form.

CSV data is in form that can be loaded directly into a spreadsheet application such as *Excel*.

DBD format is the logger's native binary format, which is generally quicker to transfer. DBD files can be opened by the dataTaker *dump_dbd* utility and certain data analysis packages.

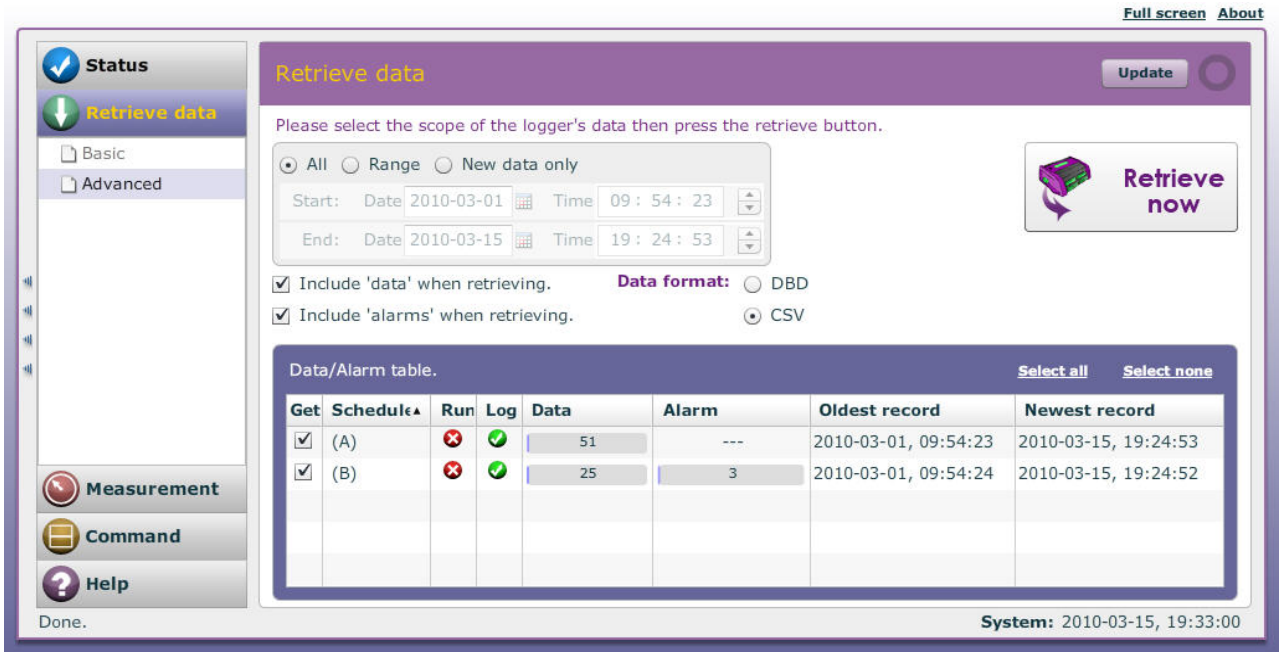


Figure 37: Retrieve Data Screen (Advanced View)

The general procedure for retrieving data is:

1. Specify the data format and the extent of the data and/or alarms to be retrieved, using the various controls (described further below)
2. Press **Retrieve Now**
3. A "Save As" dialog will be displayed where you can enter a filename. The selected data will be saved to this file in CSV or DBD format.
4. Locate the saved file and open it using a suitable application

Specifying the Data Range

Time Range

The range of data to be retrieved is specified using the control at the top of the screen. The options are as follows:

- **All** (which is the default) will retrieve all available data/alarms. The displayed start and end times indicate the approximate time range that will be retrieved. Press **Update** to update these values.
- **Range** allows you to specify an explicit date/time range. Clicking on the start or end date fields will display a calendar control, as shown in *Figure 38* below. Use the left and right arrow buttons to select the month, then click on the required day. The currently selected date is highlighted in blue, while today's date is shown in grey. Click outside the calendar control to dismiss it without changing the selected date.

  When using the Range option it is helpful to select the **Advanced** screen so you can see the time range for each schedule's logged data/alarms.
- **New Data Only** will retrieve all data logged since the last unload. As with the **All** option, the displayed start and end times indicate the approximate time range that will be retrieved. Press **Update** to update these values.

Note For the New Data Only option, "unload" means a web interface data retrieval by any browser session. In other words, "since the last unload" does not necessarily mean "since your last unload". The New Data Only feature should therefore normally only be used where data is being collected by a single web user.

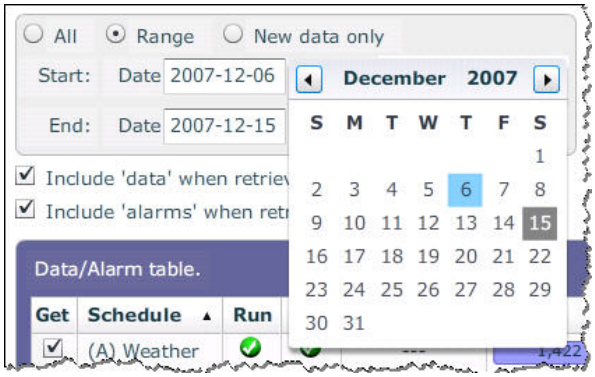


Figure 38: Date Selection Control

Data or Alarms

The two checkboxes below the range control should be self-explanatory – they select whether data, alarms or both will be retrieved. The default is to retrieve both data and alarms.

Data Format

Select DBD or CSV format. DBD will normally be faster to transfer, but CSV can be opened by more applications.

Schedules

If the **Advanced** screen is selected then a table showing the status of each schedule is shown in the lower part of the screen. This has the same format as the **Schedules** status screen, with the addition of a **Get** column containing a checkbox for each schedule.

If a schedule's checkbox is ticked than data and/or alarms for that schedule will be retrieved; if it's not then it won't.

Retrieving Data

When you click on the **Retrieve Now** button, the web interface will first query the logger to obtain an estimate of the number of records that will be returned, given the selections you have made. If the *DT80* indicates that there is no data to retrieve than a message to that effect will be displayed and the unload will be cancelled.

Next, the web interface will start the actual data download. At this point the "Save As" dialog will be displayed. Note that a default filename will be automatically generated, in the following format:

*serial_jobname_yyyymmdd***T***hhmmss***.CSV** (or **.DBD**)

where *serial* is the *DT80*'s serial number, *jobname* is the name of the current job and the rest is the date and time at which the data retrieval was performed. A different name or location may be specified if desired.

A progress dialog will now be displayed. The bar graph gives an approximate indication of the percentage completion.

Once the process is complete, "Done" will be displayed; you can now open the file using your preferred application. A spreadsheet application (e.g. *Excel*) provides many analysis and charting capabilities.

CSV Data Format

Data and alarms are returned in standard Comma Separated Value (CSV) format.

The file consists of a number of **rows**. Each row is terminated by a CR-LF sequence.

Each row consists of a number of **fields** (columns), separated by commas. (Semi-colons (`;`) will be used if the *DT80* has been configured to use a comma as the decimal point character.)

Each row consists of the following fields, in order:

- timestamp (e.g. `2007/12/15 20:49:45.905`)
- timezone. Currently, this field will always have the value "`n`", meaning "no timezone"
- data values for first schedule (zero or more fields, one for each loggable channel). Numeric data values are specified in "mixed" format (may be either standard or exponential format), to 8 significant digits and trailing zeroes after the decimal point are trimmed. String values are enclosed in quotes, with any control characters represented in `^c` form (e.g. a CR character would appear as `^M`).
- alarm number, alarm state (0-3) and alarm text (see *Alarm Records* (P84)) for first schedule (three fields; only present if schedule has one or more loggable alarm channels)
- data values for second schedule (if any)
- alarm number, alarm state and alarm text for second schedule (if any)
- (and so on, for each schedule)

The first row in the file is a **header row**, which contains a descriptive name for each field. For example, the name of a data value field has the form "*chanName* (*units*)", e.g. "`Reactor4 (degC)`"

The first block of rows after the header row contain all data records for the first schedule. The next block of rows contain all alarm records for the first schedule. Then comes the data records for the second schedule, and so on.

In other words, the CSV data is generated in schedule order, not in time order. However, once it is loaded into a spreadsheet it is a trivial exercise to re-sort by the timestamp field.

Displaying Real-Time Measurements

The web interface provides two ways of viewing real-time measurements:

- all channels can be displayed in tabular form, one row for each defined channel
- up to 6 channels can be displayed using a variety of graphical **mimic** displays

Channel List Screen

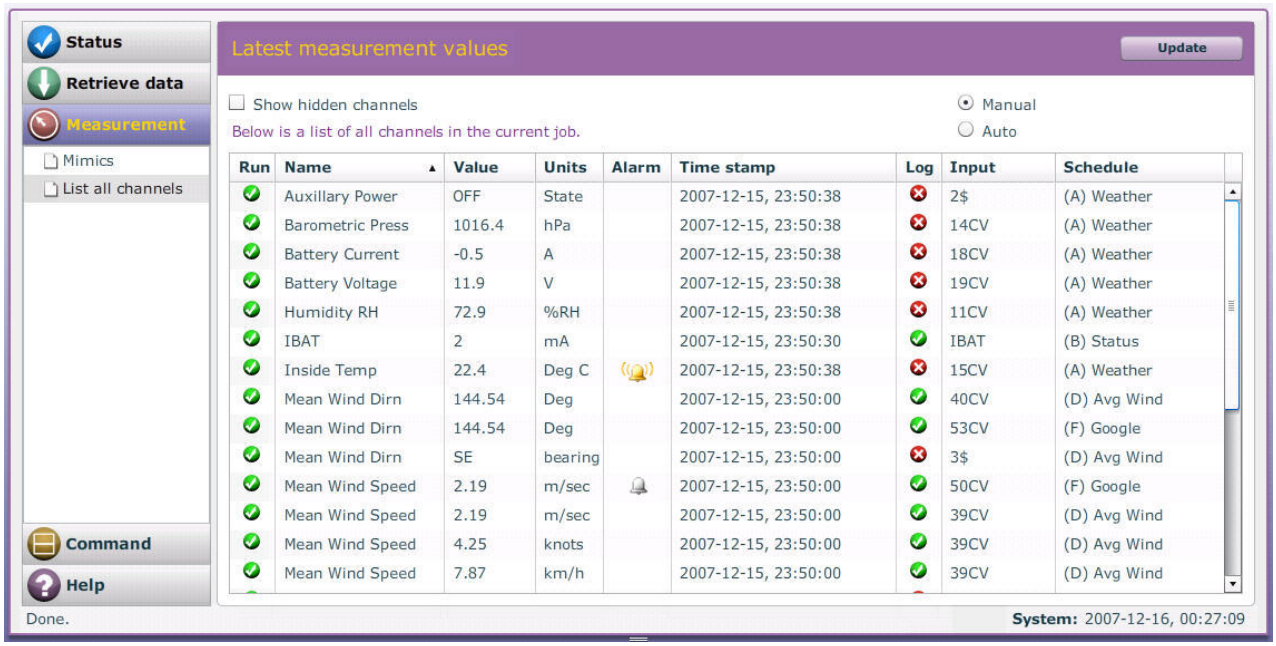

Status
Retrieve data
Measurement
Mimics
List all channels
Command
Help
Latest measurement values
Update
Show hidden channels
Below is a list of all channels in the current job.
Manual
Auto
Run | Name | Value | Units | Alarm | Time stamp | Log | Input | Schedule
Auxillary Power | OFF | State | 2007-12-15, 23:50:38 | 2$ | (A) Weather
Barometric Press | 1016.4 | hPa | 2007-12-15, 23:50:38 | 14CV | (A) Weather
Battery Current | -0.5 | A | 2007-12-15, 23:50:38 | 18CV | (A) Weather
Battery Voltage | 11.9 | V | 2007-12-15, 23:50:38 | 19CV | (A) Weather
Humidity RH | 72.9 | %RH | 2007-12-15, 23:50:38 | 11CV | (A) Weather
IBAT | 2 | mA | 2007-12-15, 23:50:30 | IBAT | (B) Status
Inside Temp | 22.4 | Deg C | 2007-12-15, 23:50:38 | 15CV | (A) Weather
Mean Wind Dirn | 144.54 | Deg | 2007-12-15, 23:50:00 | 40CV | (D) Avg Wind
Mean Wind Dirn | 144.54 | Deg | 2007-12-15, 23:50:00 | 53CV | (F) Google
Mean Wind Dirn | SE | bearing | 2007-12-15, 23:50:00 | 3$ | (D) Avg Wind
Mean Wind Speed | 2.19 | m/sec | 2007-12-15, 23:50:00 | 50CV | (F) Google
Mean Wind Speed | 2.19 | m/sec | 2007-12-15, 23:50:00 | 39CV | (D) Avg Wind
Mean Wind Speed | 4.25 | knots | 2007-12-15, 23:50:00 | 39CV | (D) Avg Wind
Mean Wind Speed | 7.87 | km/h | 2007-12-15, 23:50:00 | 39CV | (D) Avg Wind
Done.
System: 2007-12-16, 00:27:09

Figure 39: Channel List Screen

The **Channel List** screen lists all channels defined in the current job. For each channel, the following information is displayed:

- **Run** – if green then the channel's schedule is running
- **Name** – channel name
- **Value** – channel value as at the last update (press **Update** to immediately update all values)
- **Units**
- **Alarm** – If the channel is an alarm channel (i.e. the channel is the quantity being tested in an **ALARM** or **IF** command) then this column indicates the state of the alarm – active (ringing bell) or inactive (quiet bell). If the channel is not an alarm channel then this column is blank.
- **Timestamp** – the time at which the indicated value was recorded
- **Log** – if green then logging has been enabled for the channel, and its enclosing schedule.
- **Input** – the channel's default (standard) name
- **Schedule** – the name of the schedule containing this channel

By default, working channels are not displayed in the channel list. (A working channel is one with the **W** channel option specified, which means that it is not displayed, returned or logged.) However, if you tick the **Show Hidden Channels** checkbox then all channels will be displayed.

As with most other screens, the displayed information can be immediately updated by pressing **Update**. It can also be set to automatically update, by selecting **Auto** in the upper right of the screen. You can then specify the number of seconds between updates.

Note that automatic updates will only continue while the Channel List screen is displayed. If you select a different screen then the web interface will stop requesting updates from the logger.

Mimics Screen

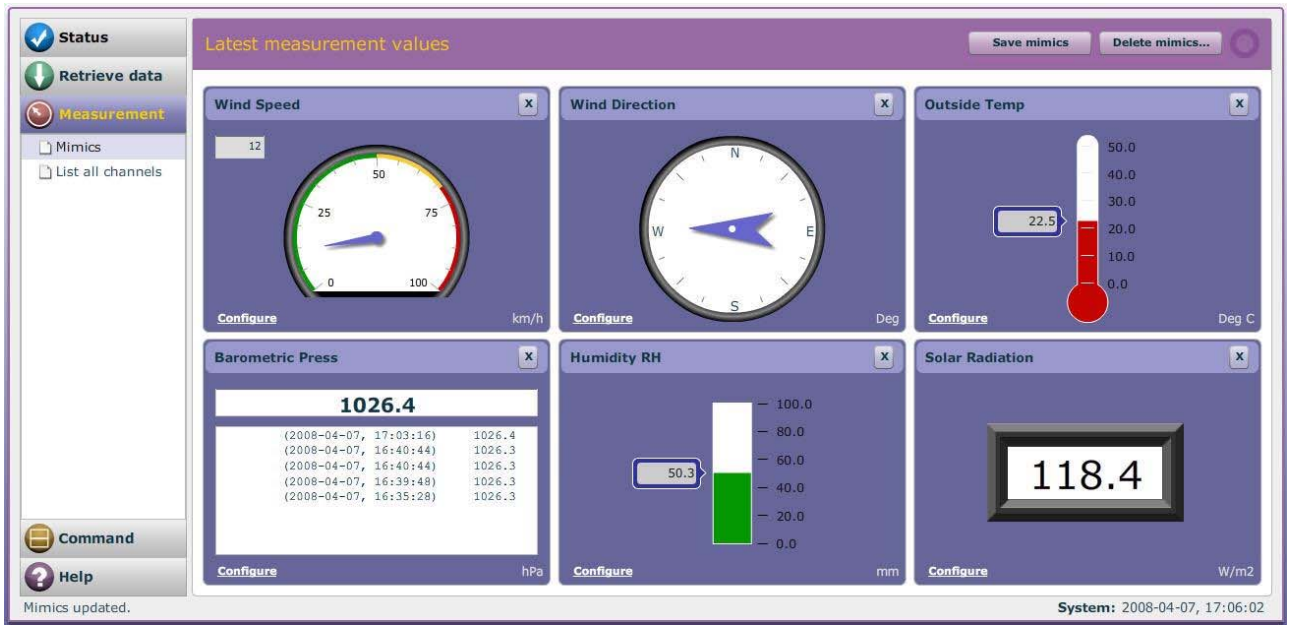


Figure 40: Typical Mimic screen

The **Mimics** screen can be used to present selected channel values in a way that resembles traditional control panel indicators.

Up to five separate mimic screens can be defined, using the web interface configuration tool (see *Customising the Web Interface* (P139)).

Each mimic screen provides space for between one and sixteen mimic displays, arranged in a grid layout, as shown in the screenshot. Initially, all display positions will be blank, with a single **Add mimic...** button in each display position. The general procedure for setting up a mimic screen is as follows:

1. First ensure that the required job is loaded and is working as required.
2. Create a mimic by clicking on the **Add mimic...** button in the desired display position. You will then fill in various details specifying the type of mimic (bar graph, meter, etc.), the channel, and various other options.
3. Repeat the above to define more mimics. If required, existing mimics can be changed using the **Configure** control. It is not necessary to define mimics for all six positions.
4. When you are happy that all mimics are working as required, press **Save Mimics**. This will save your mimic configuration to a file on the logger. The next time you connect to that logger (using any PC), your mimic setup will be automatically retrieved and displayed.

Types of Mimics

Eight different types of mimics are available:

- **Dial Meter** – a pointer which moves across a graduated scale
- **Bar Graph** – a variable height vertical bar with a graduated scale
- **Thermometer** – a bar graph in the shape of a bulb thermometer
- **Compass** – a circular compass display for indicating a bearing in degrees
- **Digital Panel** – a numeric display, similar to a digital panel meter
- **LED** – simulates a single or bi-colour LED
- **State Indicator** – indicates one of two states using two LEDs
- **History List** – displays a numeric value, along with previous samples
- **Chart** – displays a trend chart for one or more channels

On each mimic page you can present 1-16 channels using any combination of these mimic types.

Creating a Mimic

To create a mimic, choose one of the six display positions and click the **Add Mimic...** button. If you want to replace an existing mimic, then you will first need to delete the old one by clicking on the **X** button in the top right of the mimic's display position.

When you click on **Add Mimic...**, a dialog box will be displayed (*Figure 41*) where you can specify

- the type of mimic
- the channel whose value you want to display

Once these have been set, press **OK** to create the mimic.

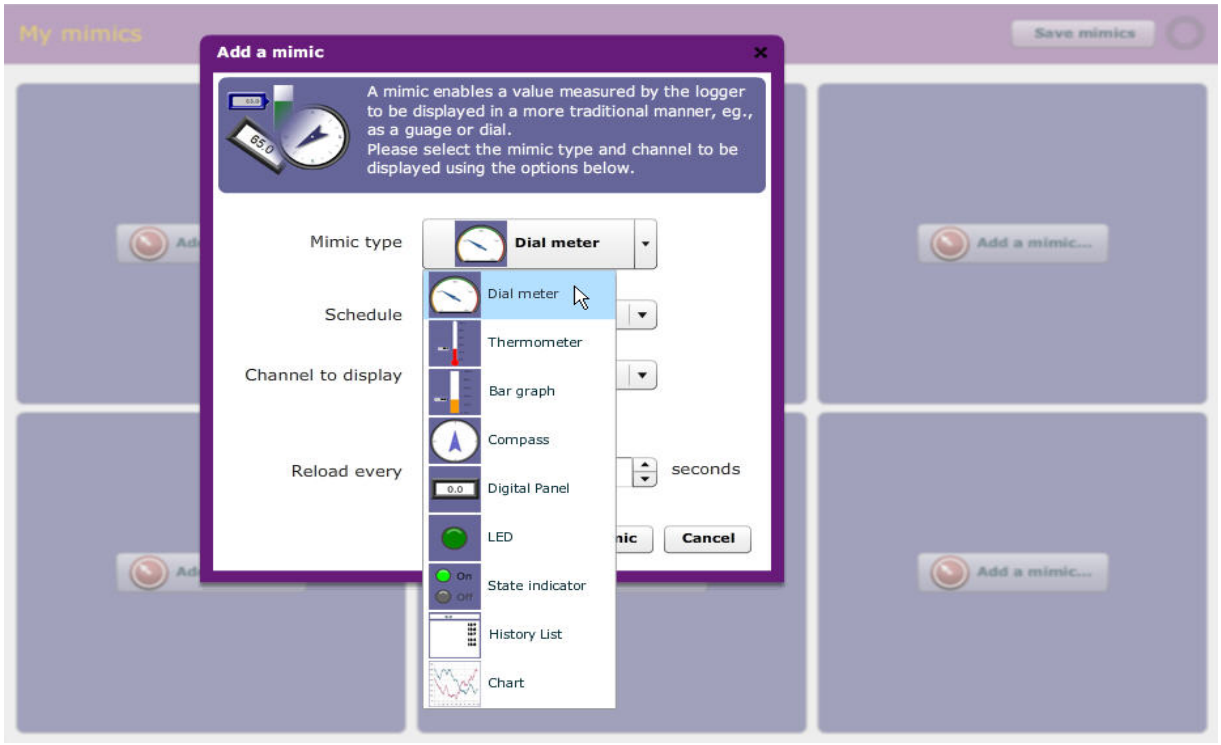


Figure 41: Mimic creation dialog

Configuring the Mimic

Once a mimic has been created, it will be displayed in the selected position and will begin automatically updating at the default rate, or the rate you set on the mimic creation dialog.

You can now change various aspects of the mimic by clicking on the mimic's **Configure** link in the lower left corner. This will bring up a configuration dialog box. The contents of this dialog will vary according to the mimic type. A typical mimic configuration dialog (for the Dial Meter type) is shown in *Figure 42*.

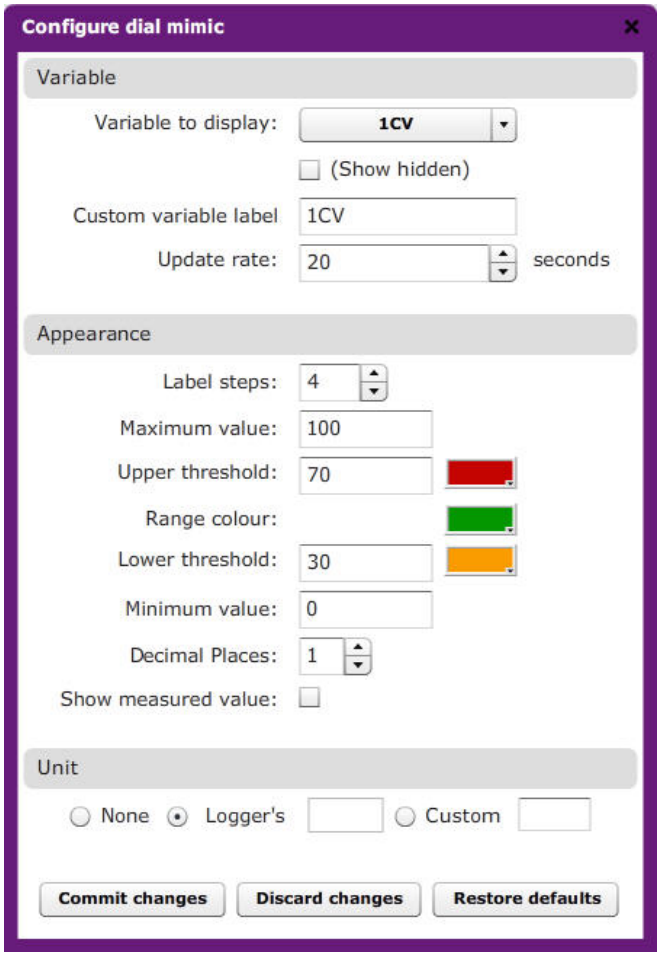


Figure 42: Configuration dialog for Dial Meter mimics

For a given mimic type, the configuration settings may include:

- **Variable to display** – specifies the channel to display
- **Custom variable label** – the name of the channel (as set on the logger) can be overridden here
- **Update Rate** – specifies how often the mimic will request an updated channel value from the logger
- **Units** – this text string will be displayed in the lower right corner. Typically this would be set to **Logger's** to display the channel's units string as specified in the logger program.
- **Minimum**, **Maximum**, **Label Steps** – defines step size and extent of graduated scale for those mimic types that have one (Bar Graph, Thermometer and Dial Meter)
- **Upper threshold, Range colour, Lower Threshold** – divides the range of the mimic into three bands; a separate scale or indicator colour can be specified for each band.
- **Decimal Places** – number of digits after the decimal point in channel value when displayed numerically
- **Show Measured Value** – for mimic types which do not display the numeric channel value as part of their main graphic, this option allows you to include a small numeric channel value display.
- **Threshold** – for bi-state mimic types (State Indicator and LED), the mimic will be displayed in the "active" state if the channel value exceeds this threshold value
- **Colour** – for some mimic types, the colour of the main graphic element can be adjusted. For bi-state mimics, both the "active" and "inactive" colours can be specified.
- **Size** – for some mimic types, the size of the main graphic element can be adjusted (LED radius, bar graph width, panel meter font size, etc.)
- **State Labels –** for State Indicator mimics, you can customise the text displayed next to each LED.

Once all required mimics have been created and configured, press **Save Mimics** (top right), which will save your mimic setup to a file on the logger.

Note that only one mimic configuration can be stored on the logger. When you press **Save Mimics**, any previously stored mimic configuration will be overwritten.

Saved mimics will be automatically reloaded whenever you connect to the logger using the web interface and display the Mimics screen.

Chart Mimics

About Charts

The trend chart mimic is the most sophisticated of the mimic types. It can retrieve historical data from the *DT80* and plot one or more channels on a "chart recorder" type display.

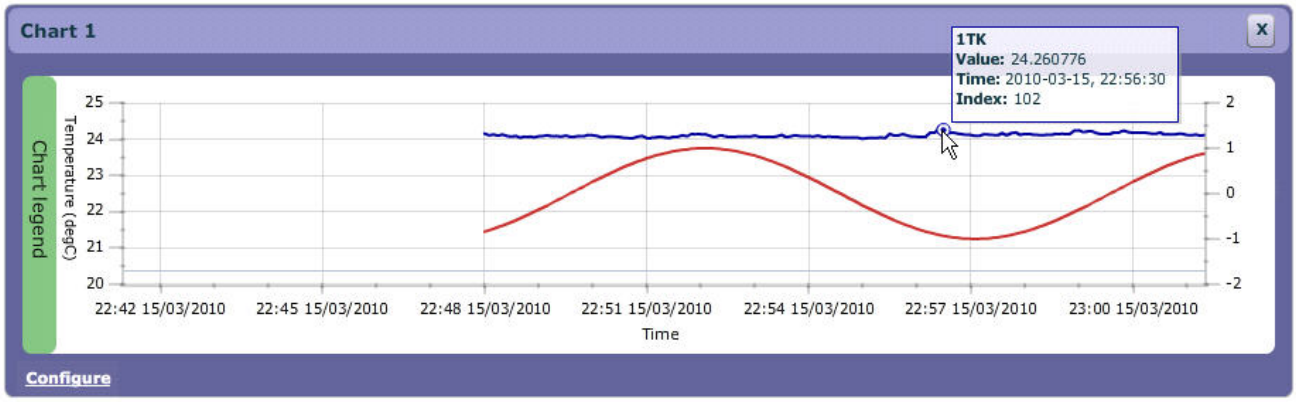


Figure 43: Typical chart mimic

Up to 5 different channels can be plotted on each chart mimic, and up to two Y axes can be defined.

The above screenshot shows a typical chart mimic shortly after the job was started. The chart has been configured to show the last 20 minutes worth of data, and the job has been running for about 12 minutes. The blue trace (temperature) uses the left hand axis, while the red trace (sine wave) uses the right hand axis.

The Y axis range can either be set manually (as is the case here) or automatically.

Moving the cursor over a trace will display details of an individual sample point, as shown in the screenshot, while moving the cursor over the green area on the left will display a legend showing the channel name for each trace colour.

Each trace stores and displays up to 1000 data points, which may be fewer than the actual number of data points logged over the displayed time interval. If this is the case then the trend chart will actually show a sample of the actual logged data. Be aware that this sampling of the data may cause narrow peaks in the data to be missed, and not displayed.

Defining a Chart

Defining a chart is similar to defining any other mimic. Click the **Add a mimic...** button on any unused mimic space, which will bring up the mimic creation dialog (*Figure 41*). Select **Chart** as the mimic type and press **Create mimic**.

After creating the mimic, click the chart mimic's **Configure** button to bring up the chart configuration dialog.

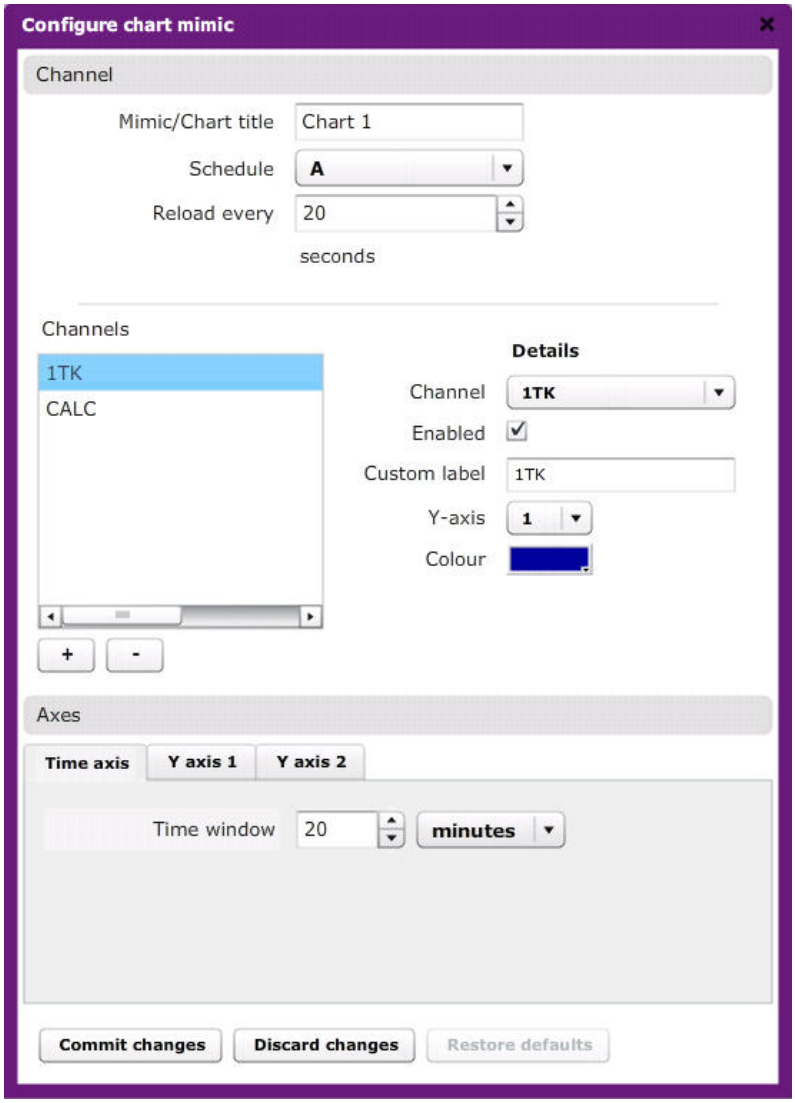


Figure 44: Chart configuration dialog

The dialog has three main parts:

- In the top part, select the schedule from which this chart's channels will come (all channels plotted on the one chart must be part of the same schedule). Also specify the reload interval - the web interface will request new data from the *DT80* at this rate.
- The centre part of the dialog lists the traces that will be plotted. Use the + and – buttons to add or remove traces from this list. Remember that only channels from the selected schedule will be available to add.

  Details for the selected trace are displayed on the right hand side, including the source channel, a label (defaults to the channel name), trace colour and the Y axis (1 or 2) against which it will be plotted.
- The lower part of the dialog has a tab for the time axis and the two Y axes. For the Y axes you can specify manual or automatic scaling and the axis label.

Press **Commit changes** to apply the indicated settings.

Don't forget to press **Save mimics** (top right of the screen) to save all mimics to the logger – otherwise they will be lost when you close or reload the browser window.

Remapping Mimics

If you make a change to a configuration that already has mimics defined then *dEX* will attempt to **re-map** the mimics to the new configuration, according to the following rules:

- If there is a channel in the new configuration that has the same name as the mimic's configured channel then the mimic will be automatically remapped to that channel.
- Otherwise, a window will pop up giving you the option to either (a) delete the mimic, or (b) manually remap it to one of the channels in the new configuration.

For example, suppose you have defined a configuration with two channels: "1CV" and "Temp", and have then defined three mimics: a panel meter showing 1CV, a thermometer showing Temp and a chart showing both.

If you now change the configuration so that "Temp" is renamed to "KilnTemp", then a dialog box similar to the following will be displayed:

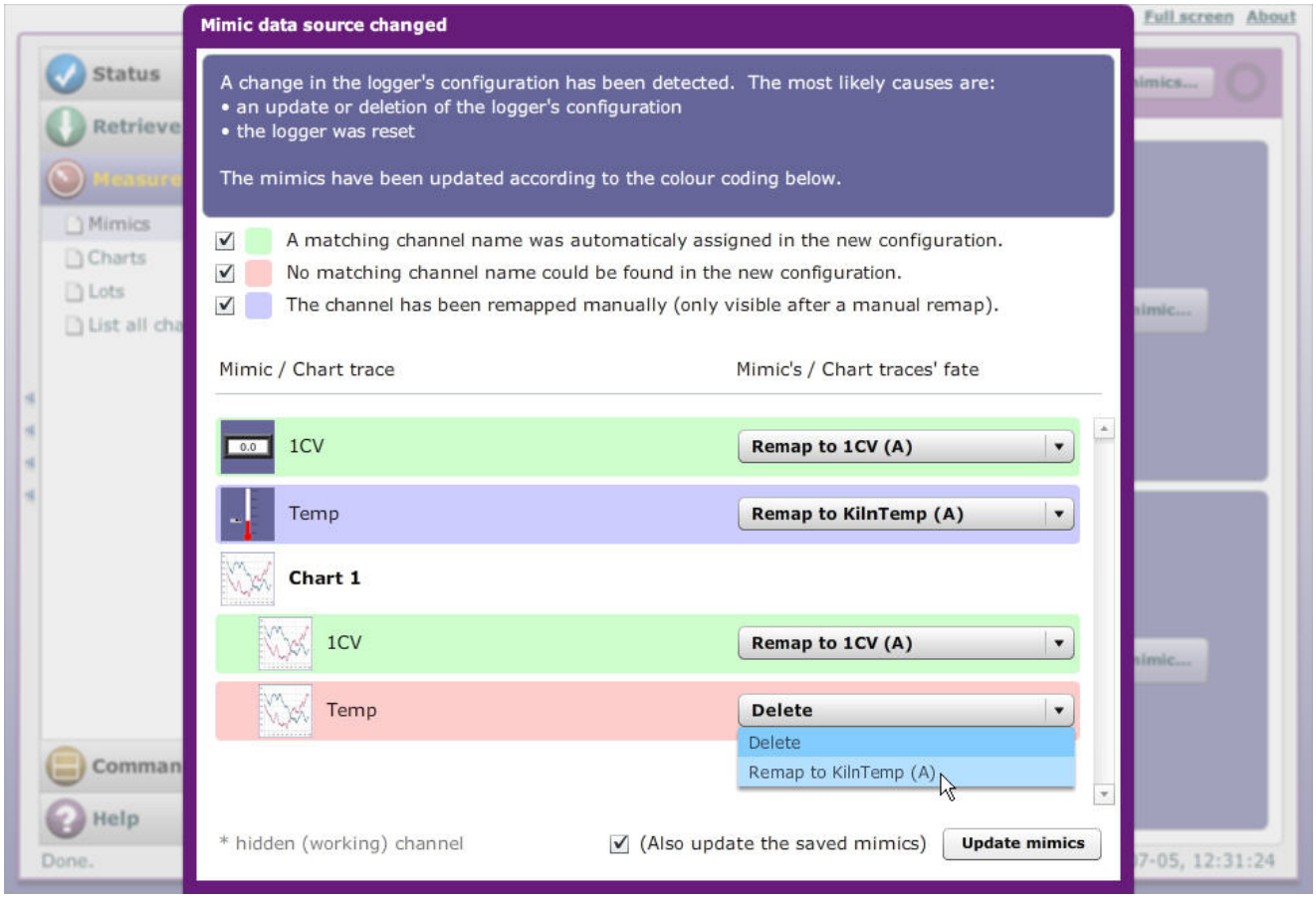


Figure 45: Mimic remapping dialog

This window lists all defined mimics and chart traces. If a channel with matching name was found in the new configuration (as is the case for the 1CV panel meter and chart trace) then the mimic is displayed in green and the mimic is automatically remapped to the matching channel.

If there is no channel with the same name in the new configuration then the mimic will be displayed in red.

For each mimic or trace, select whether you want to delete the mimic or remap it to one of the new configuration's channels ("1CV" or "KilnTemp"). If you choose to remap a mimic to a new source channel (as is the case for the thermometer mimic) then the mimic is displayed in purple.

Once this has been done for all mimics in the list, press **Update mimics**.

By default, the updated mimics will be automatically saved to the logger. If you don't want this to happen (e.g. the change you made to the configuration was a temporary test only) then clear the **(Also update the saved mimics)** checkbox.

Note If matching channels can be found for all defined mimics then the mimic remapping dialog will not be displayed.

Command Window

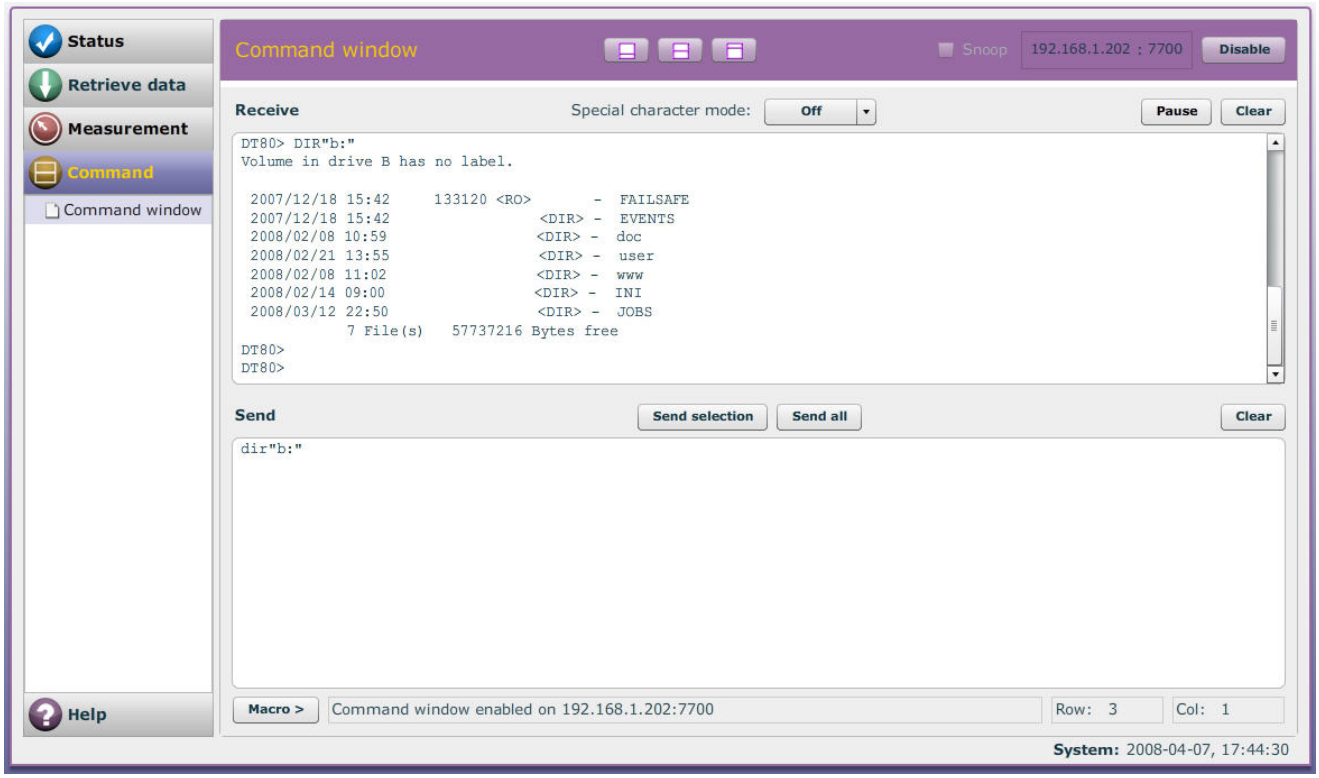


Figure 46: Command Window

The **Command Window** screen provides access to the *DT80*'s command interface. This allows you to send commands to the *DT80* and see its responses, much as you would using *DeTransfer*. In the above screenshot, the command window has been used to send the **`DIR"B:"`** command (seen in the lower **Send** pane) and the logger's response has been captured in the upper **Receive** pane.

Enabling the Command Window

When the Command Window is first selected, it will be **disabled**, and it will not be possible to type anything in the **Send** pane. To enable the command interface, you need to first select the mode: **Normal** mode (default) or **Snoop** mode (tick the checkbox), then press **Enable**.

In Normal mode, the web interface will automatically send the sequence **`/h/E/M/R`** when you press the **Enable** button. This makes the command interface easier to use by ensuring that fixed format mode is switched off (**`/h`**), and that command echo, messages and data return are switched on. When you subsequently press **Disable** or select a different screen, the web interface will send **`/e/m/r`**.

In Snoop mode, nothing is sent when you enable or disable the interface. This allows you to "snoop" a logger to see what it is outputting, without affecting its state.

The box to the right of the **Snoop Mode** checkbox indicates the IP address and TCP port number to which the command window is "connected". These are not editable.

The three purple buttons above the Receive pane allow you to change the relative sizes of the Send and Receive panes.

Note If you switch to a different web interface screen then the command window will be automatically disabled. If you then return to the Command Window screen, it will be automatically re-enabled in the same mode (Normal or Snoop). The contents of the Send and Receive panes will have been preserved. (They will, however, be cleared if you reload the web interface, e.g. by pressing the browser's Refresh/Reload button.)

Sending Commands

Once the command window has been enabled, you will be able to type standard *DT80* commands into the lower **Send** pane. Controls will be familiar to *DeTransfer* users:

- Entered text is not sent to the logger until you press Enter or click one of the "Send" buttons
- Press Enter to send to the logger all text on the line on which the cursor is positioned.
- Click **Send All** to send all text in the Send pane to the logger
- Click **Send Selection** to send all text in the Send pane that you have highlighted.
- Press Shift-Enter to insert a line break. Nothing will be sent to the logger. This is useful for entering a sequence of commands or a multi-line job which you will later send all in one hit.
- The Windows copy and paste mechanism may be used to paste text into the Send pane.

- Click **Clear** to erase all text from the Send pane.

Note to *DeTransfer* users: The web interface command window does not interpret any "backslash" sequences. This means that to send a "****" character to the logger you enter "****", not "****".

Viewing Logger Output

Once the command window has been enabled, all output from the logger's command interface will be displayed in the top **Receive** pane.

The Receive pane has a 32 kbyte memory buffer for storing received text. As text is received, it is added to the buffer. Once the buffer becomes full, the oldest data is discarded.

The Receive pane normally displays the newest received data, but you can review data which has scrolled out of the display are by using the scroll bars. However, if data is being returned quickly then this will be awkward because the Receive pane will keep jumping back to display the newest data.

The **Pause** button is useful here – it temporarily stops screen display updates so you can scroll back through the receive buffer. Note that incoming data will still be captured while the screen is paused. When you un-pause the display (by clicking on the **Pause** button a second time) all captured text will be added to the receive buffer and displayed.

Other Features

Special Characters

The **Special Character Mode** control specifies how incoming control and non-printable characters are handled. When this control is set to **Off**, all characters are written to the receive buffer "as is". When set to one of the other values, any incoming characters with ASCII codes in the range 0-31 or 127-255 will be replaced by a text string identifying the character. For example, if **Decimal** is selected then an incoming ESC character (ASCII 27) will be replaced with the string `[27]`.

To send a special character, enter the special sequence **_char(***n***)**, where *n* is the required ASCII code (1-255) in the Send window at the point you want the special character to be inserted. For example:

```
1$="abc_char(88)def"
```

will result in 1$ being set to **abcXdef** (character "X" has ASCII code 88)

Delays

It is sometimes useful to insert a delay between commands. This can be done using the special sequence **_wait(***n***)**, where *n* is the number of seconds to wait. This command must be specified on a line by itself. For example, if you enter the following in the Send pane:

```
HRESET
_wait(5)
DIR
```

and press **Send All**, then the web interface will send **HRESET**, pause for 5 seconds, then send **DIR**.

Macros

If the mouse cursor is moved over the status line area at the bottom of the screen then a set of six **macro** buttons will appear, labelled, by default, **Macro 1** through **Macro 6**. These buttons allow you to save commonly used command sequences and then send them with a single click.

To define a macro button, hold down the Ctrl key and click one of the buttons. A window will pop up, allowing you to set:

- the label for the button
- the commands to send (**_char** and **_wait** sequences may be included)
- other options, such as whether you want to be prompted before the command is sent

Pressing **Save** will save the macro definitions to a file on the logger, from which they will be automatically retrieved when you next connect to that logger.

Help

These screens provide:

- some general tips on using the web interface
- links to documentation files (user manual, release notes, etc.) stored on the logger.
- links to video tutorials stored on the logger.
- links to useful resources on the Datataker web site (www.datataker.com)
- information on how to report a problem or get help

The video tutorials give an introduction to the enhanced web interface. These files may have been pre-installed on your *DT80* but are not normally included in firmware upgrade packages. Note that the files take up a significant fraction of the available internal storage space. If they are no longer required then they can be deleted using the **DELVIDEOS** command.

Customising the Web Interface

Overview

Several aspects of the enhanced web interface can be customised to suit site requirements:

- Selected menu items can be disabled to help prevent unauthorised or accidental changes to the logger configuration. For example, access to the Command window can be removed.
- Up to 5 mimic screens can be defined, each with up to 16 mimics.
- Help pages can be customised to provide site specific information, OEM details, etc.
- The default *dataTaker* "branding" of the interface can be replaced. For example, if you are an integrator or OEM you could place your company logo and web links into the banner area of the web interface.
- Users can be prevented from adding or editing mimics.

The Web Interface Configuration Tool

To run the Web Interface Configuration Tool, select **Customise dEX** on the **Logger home** page (*Figure 22*). This will display a pop-up window, similar to that shown below.

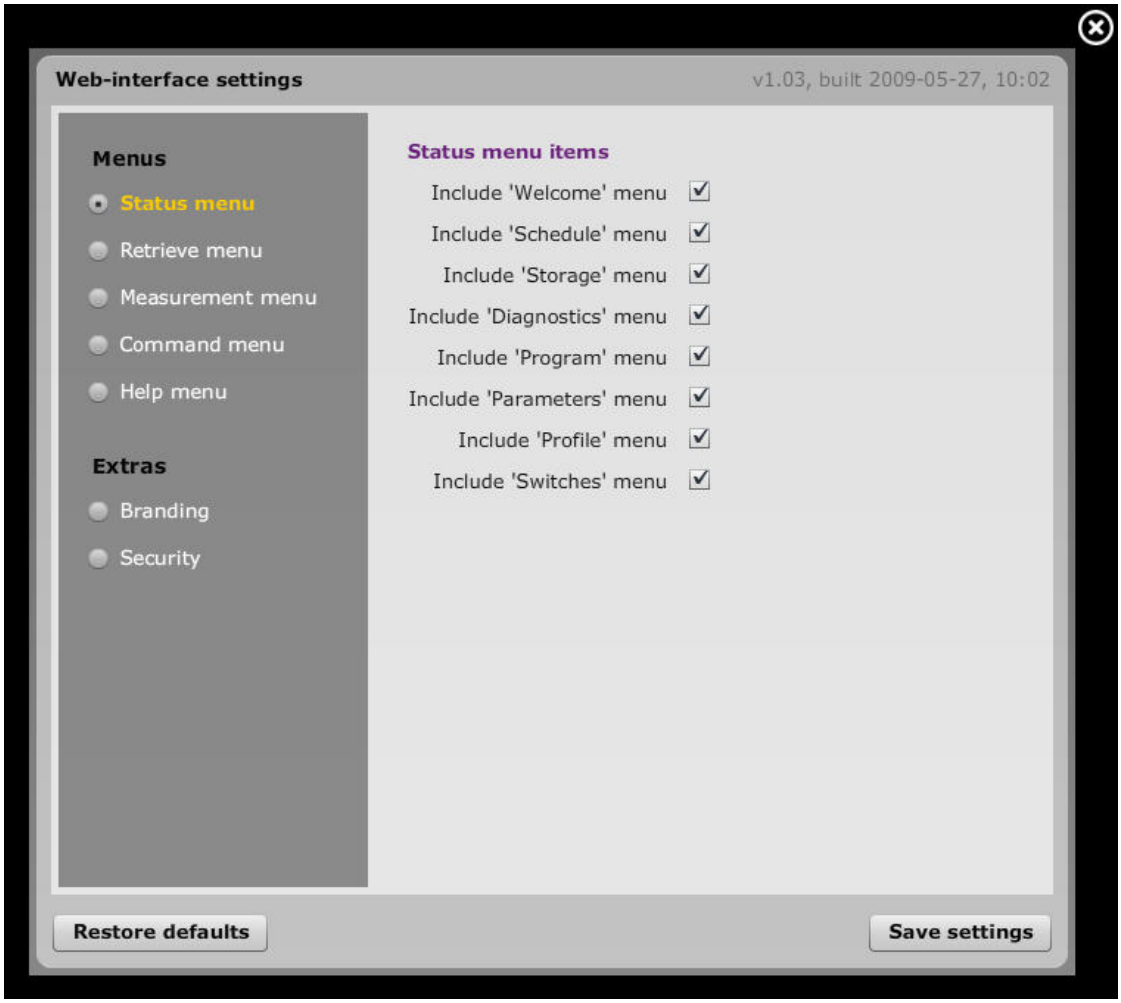


Figure 47: Web interface configuration tool

The configuration tool is laid out in a similar way to the web interface itself. There is a menu of options down the left hand side which allow you to switch between different categories of settings. The pane on the right displays settings related to the selected category.

The **Save settings** button at the lower right will save all settings to the logger. This only needs to be done once; it is not necessary to save the settings for each category separately. After pressing the Save button, you should see a confirmation message pop up after a few seconds.

The **X** symbol at the top right will close the configuration tool and return to the **Logger home** page. Any changes made since you last pressed **Save settings** will be discarded.

Finally, the **Restore defaults** button at bottom left will reset all settings to factory defaults, and save them to the logger. See also *Restoring Factory Settings* (P142).

Status menu

The settings in this category allow items in the web interface's **Status** menu to be selectively disabled.

For example, if you wish to prevent the current *DT80* program being viewed via the web interface then you should uncheck the **Include 'Diagnostics' menu** and **Include 'Program' menu** options (as well as the **Command** menu; see below)

Retrieve menu

These settings allow **Retrieve** menu items to be disabled.

Unchecking the two options ('basic retrieve' and 'advanced retrieve') in this category will prevent users downloading data from the *DT80* to their computer.

Measurement menu

The settings on the **Measurement menu** page allow you to:

- create or delete mimic pages.
- disable the **List all channels** menu item in the web interface (which displays channels and values in tabular form)

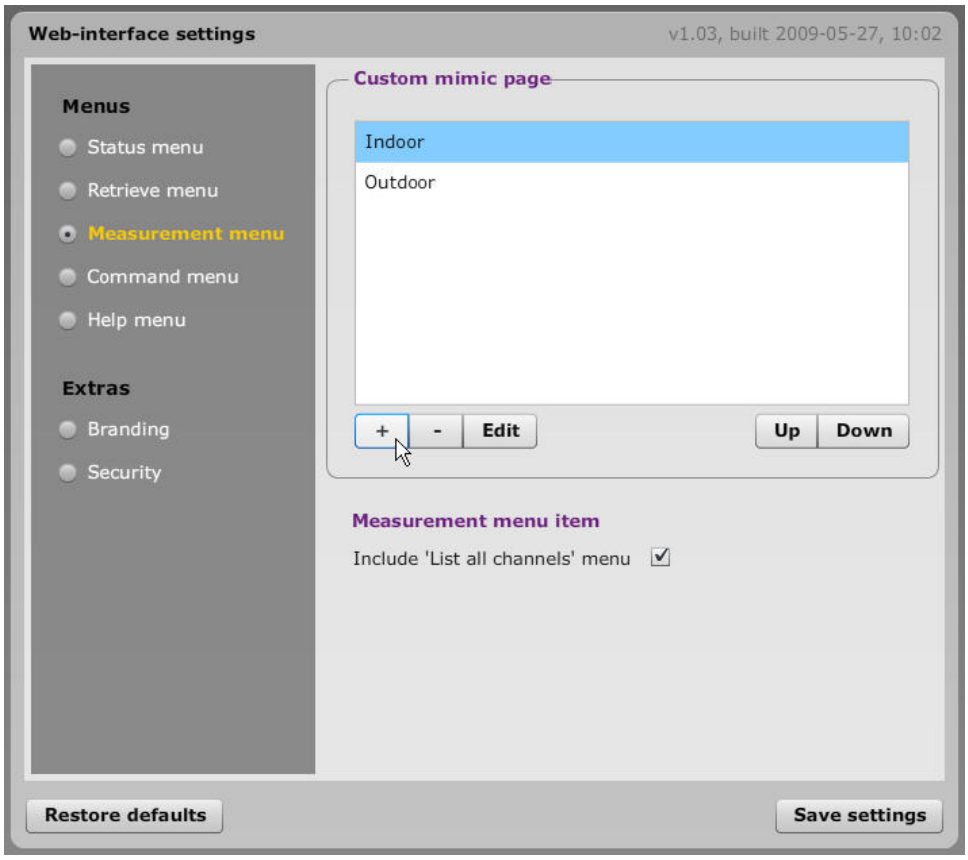


Figure 48: Customising mimic pages

By default, the web interface provides a single mimic page, which has space for up to 6 mimics arranged as 2 rows x 3 columns, as depicted in *Figure 40*.

Up to 5 mimic pages can be defined, and each can have its own arrangement of mimics, from one single mimic up to a 4x4 grid of mimics.

The **Custom mimic page** area of this screen lists the names of the currently defined mimic pages – these names will appear in the web interface **Measurement** menu. In the example shown in *Figure 48*, two mimic pages have been defined, one called **Indoor** and one called **Outdoor**.

To add a mimic page, click the **+** button, or to edit an existing page click on the page's name, then click **Edit**. A dialog box will be displayed allowing you to set the page's name, description (which the web interface will display in the title area directly above the mimics), and layout (number of rows and columns).

To delete a page, click on its name and press **–**. To change the order in which they will be displayed, click on the page's name, then click **Up** or **Down**.

Command menu

This page simply allows you to disable the web interface's command window.

Help menu

This page is similar to the **Measurement menu** settings page, in that it allows you to:

- disable some or all of the standard help pages (that is, disable some or all of the items on the web interface's **Help** menu)
- create custom help pages, which will be accessible under the web interface's **Help** menu.

Custom help pages are text files which you will need to create using a text editor. As well as plain text, these files may also contain certain HTML tags, which allows for some basic formatting (bold, italic, bullet points etc.) as well as web links, as depicted in the somewhat contrived example below.

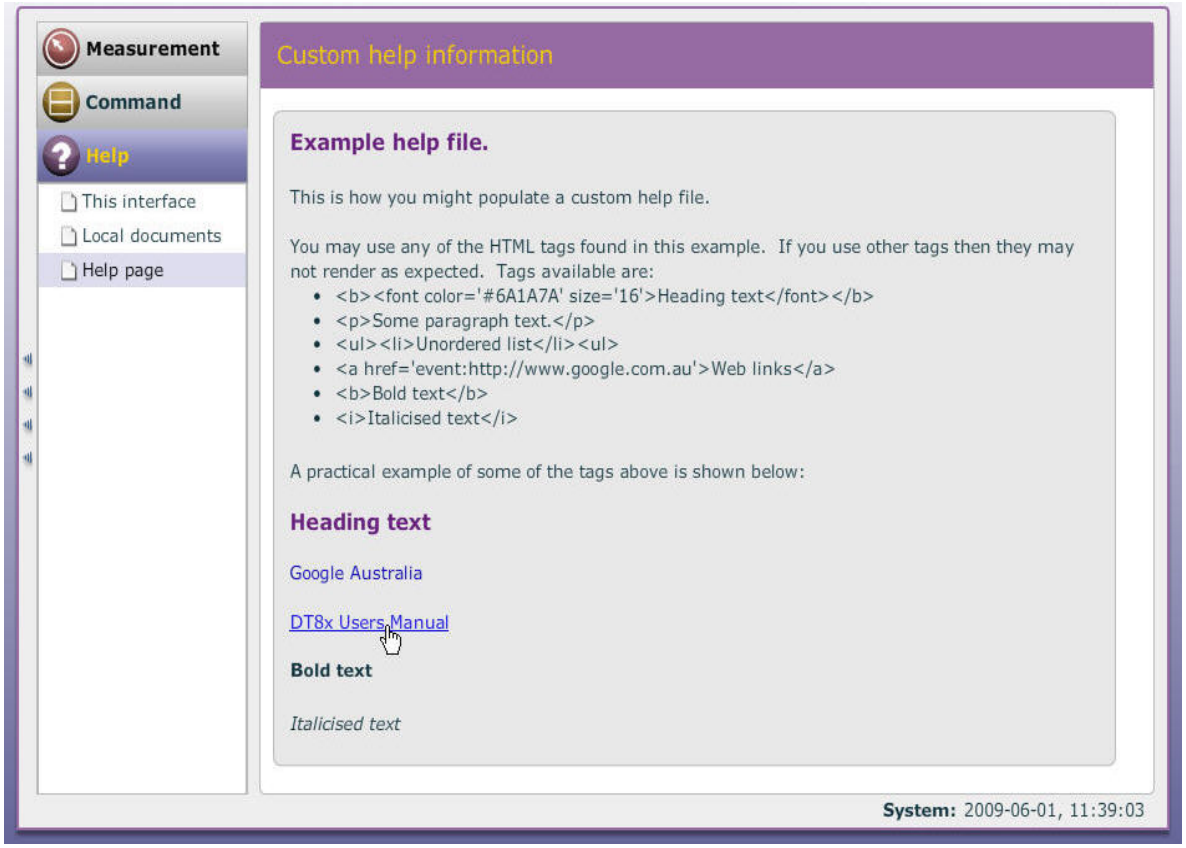


Figure 49: Sample custom help page

If you wish to create a help file with HTML formatting, the easiest way to get started is probably to download the file **`b:\www\flash\customHelp\customHelpExample.html`** (which generates the sample help page shown in *Figure 49*) from the *DT80* to your PC and use it as a starting point. This can be done by entering the following URL into a web browser:

`ftp://`*ip-address*`/www/flash/customHelp`**

then right clicking on the file **customHelpExample.html** in the displayed file list and selecting **Save Link as...** or **Save Target as...**

Once you have created and saved a help file on your PC, you can add it using the **Help menu** page in the web interface configuration tool. As with the **Measurement menu** page, click **+** to add a help page, enter a name and description, then click on the **Source** field and select **Load help page from computer**. You can then navigate to the required file, and it will be automatically uploaded to the *DT80*.

If you need to edit an existing help page, first make the changes to the copy on your computer, then select the help page from the list and press **Edit**. As before, select **Load help page from computer** and navigate to the (updated) file, which will then be uploaded to the logger, thereby replacing the old version.

Note If you upload a new version of an existing help page, as described above, it is necessary to clear the browser cache before running the web interface. This will force the browser to load the new page rather than its older cached copy. (In Internet Explorer, clear the cache by selecting "Delete Browsing History..." then select "Temporary Internet Files".)

Branding

The **Branding** category allows you to customise certain visual elements on the web interface. Currently, this is limited to the colour used for the thin border around the interface, and in the thick band above the main properties pane (by default, purple)

Security

The **Security** settings allow you to:

- disable all changes to defined mimics. This means that the **Add a mimic** buttons, as well as existing mimics' **Configure** and Close (**X**) controls (see *Figure 40*) will no longer be present.
- disable full screen mode, which will remove the **Full screen** link at the top right of the screen.

Preventing Configuration Changes

Once the web interface has been fully configured, you can set up the *DT80* so that the **Logger home** screen is bypassed, which effectively prevents users from running the configuration tool. To do this you can change the web server "document root" to point directly to the enhanced user interface, as follows:

```
PROFILE HTTP_SERVER DOC_ROOT=B:\\WWW\\FLASH\\
```

(If entered using *DeTransfer*, use `\\\\` rather than `\\`.)

This means that when a user enters `http://`*ip-address* into their browser, they will jump straight to the enhanced web interface, thereby bypassing the **Logger home** page. Note that this will also prevent users from running the classic web interface.

Restoring Factory Settings

The configuration tool's **Restore defaults** button will restore the enhanced web interface to the default look and functionality. However it will not delete any images or custom help pages that you may have uploaded to the *DT80*. If required, these can be manually deleted from the `B:\WWW\flash\images` and `B:\WWW\flash\customHelp` folders using the `DEL` command (see *File Commands* *(P106)*).

Classic Web Interface

The *DT80* classic web interface is standards compliant which helps to make the interface accessible from a wide variety of web browsers. It has also been designed to be usable even on small-screen devices such as PDAs and mobile phones.

For advanced users, the web interface can also be customised by developing new web pages and loading them onto the *DT80*'s internal file system.

Browser Requirements

The web interface uses a minimum of browser functions to provide its interface. The browser must however support XHTML 1.0, CSS 1 and JavaScript to fully support the DT80's web interface.

The following browsers have been used and found to be compatible

- *Microsoft Internet Explorer* Version 6 or later
- *Mozilla Firefox*
- *Google Chrome*
- *Pocket Internet Explorer* (on Windows Mobile 5 and Windows Mobile 2003)
- *Opera* 8.x or later, *Opera Mobile* and *Opera Mini*
- *Apple Safari*
- *Mobile Explorer*
- *Palm Web Browser* 2.x (Palm Garnet OS)
- Sony PlayStation Portable Web browser

Navigating the Web Interface

The built-in web interface consists of the five pages – **Home**, **Details**, **Status**, **Admin** and **Help**. The design of the web interface follows a tab based metaphor where each tab represents a HTML page.

Figure 50: Navigation tabs

To navigate the web interface, simply click on the desired tab heading. The Home page is displayed by default when the web interface is first loaded.

Home Page

The **Home** page displays the data logger's model, firmware version, serial number, the current job name and the current date and time.

Figure 51: Home page

The page does not provide any functionality other than the display of data logger general information.

Channels Page

The **Channels** page displays a table listing all channel entries defined for the current job. This table shows the most recent measurement for each channel, along with the time that the measurement was taken.

Note that any channels defined as working channels (**W** channel option) will not be included.

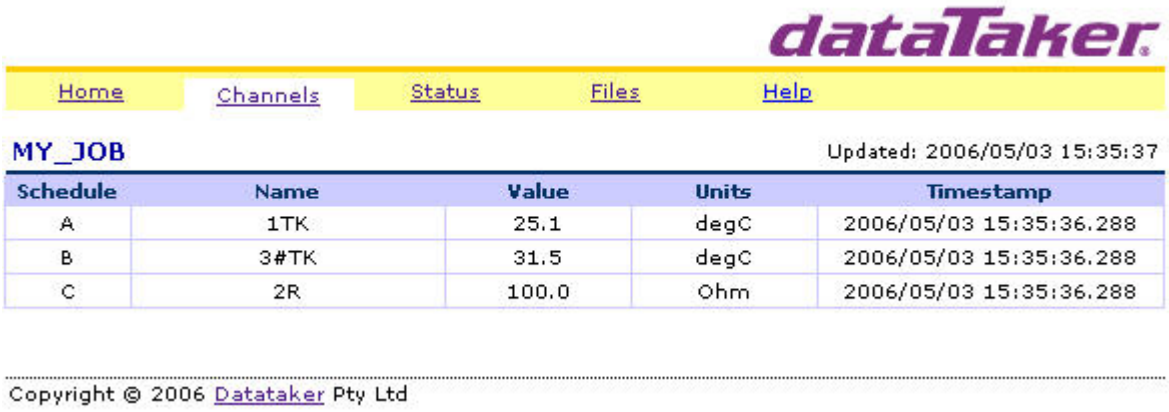

dataTaker
Home
Channels
Status
Files
Help
MY_JOB
Updated: 2006/05/03 15:35:37
Schedule | Name | Value | Units | Timestamp
A | 1TK | 25.1 | degC | 2006/05/03 15:35:36.288
B | 3#TK | 31.5 | degC | 2006/05/03 15:35:36.288
C | 2R | 100.0 | Ohm | 2006/05/03 15:35:36.288
Copyright © 2006 Datataker Pty Ltd

Figure 52: Channels Page

The Channels page is updated every 30 seconds. The time at which the table was last updated is displayed on the top-right corner of the channel listings table.

Status Page

The **Status** page displays status information for each defined schedule in the current job. The following information is displayed for each schedule:

- Schedule Name
- Schedule Trigger
- Schedule Status – whether it is active or halted.
- Schedule Logging State – enabled or disabled
- The number of data records / alarms logged
- The capacity of the schedule's store file
- The timestamp for the first and last data / alarm records stored

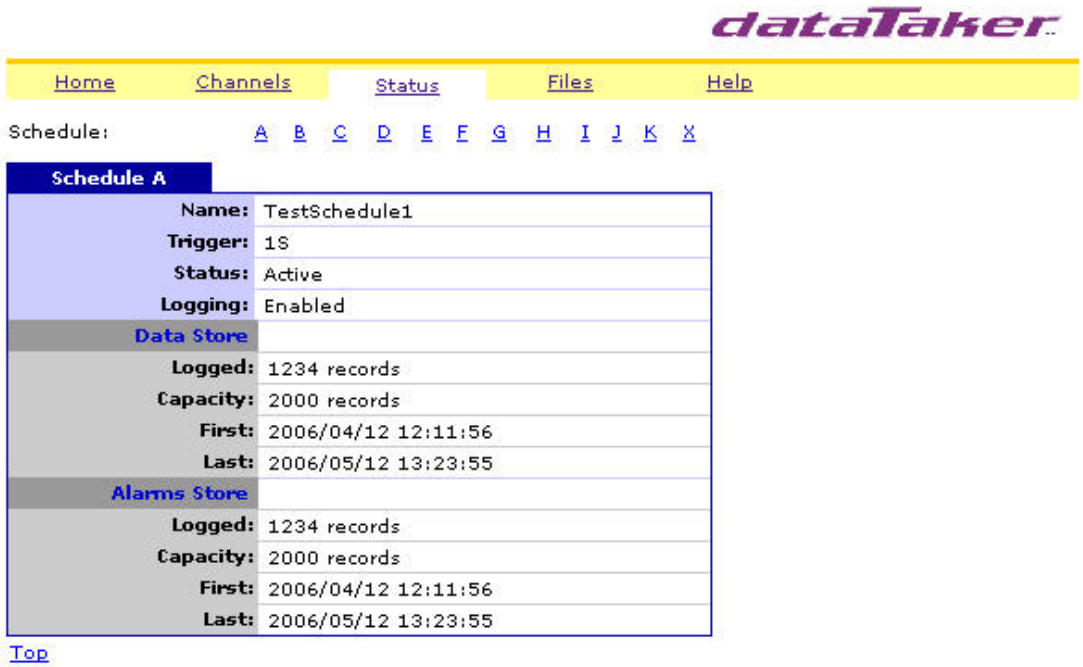


Figure 53: Status Page

All schedules configured for the current job will be displayed when this page is loaded.

The schedule navigation links at the top of the page (A – X) allow you to jump directly to a particular schedule.

Finally, the Top link displayed below each schedule's data provides a quick way to scroll back to the top of the page.

Files Page

The **Files** page provides the ability to view files stored on the *DT80's* file system. Direct links are provided for the system event and error logs (see *Event Logs* (P213)), and the remainder of the file system can be browsed using FTP.

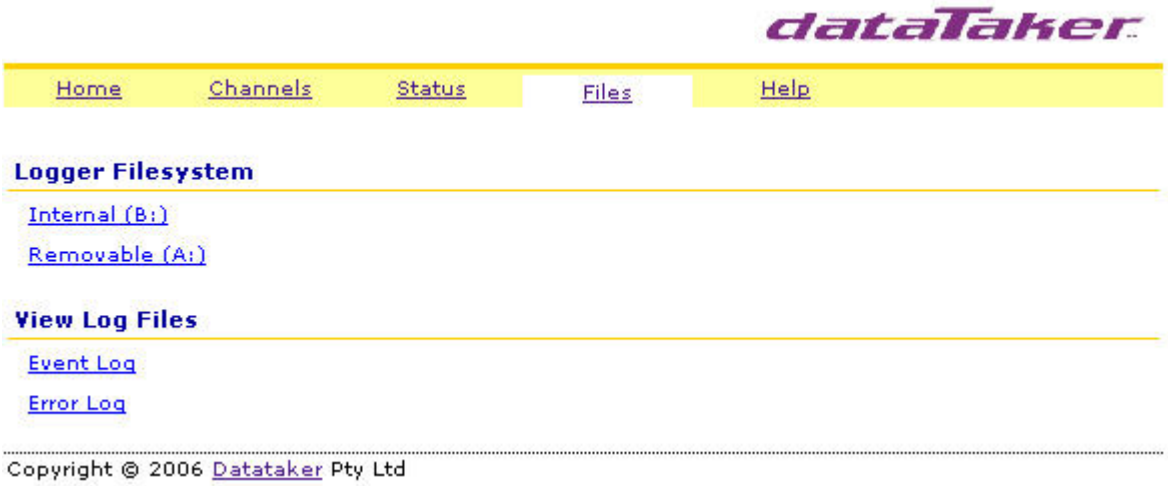


Figure 54: Files Page

To view a log file, simply click on the desired log file link. The log file will then be displayed. Click on the Back link to return to the Files page.

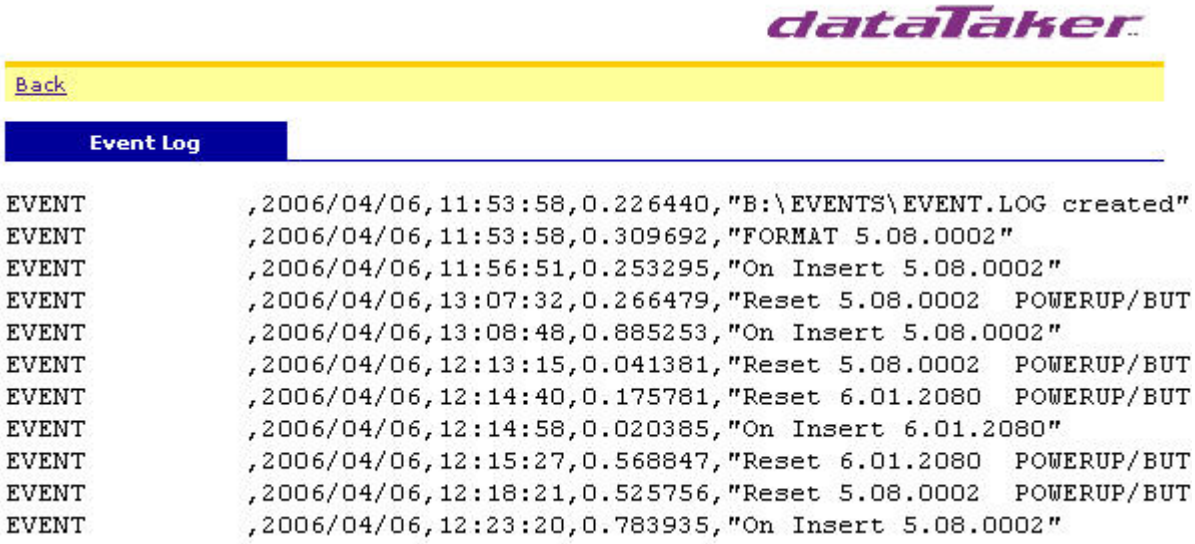


Figure 55: Event Log Page

To access files stored on the *DT80*'s internal file system, or in a connected USB memory device, click on the desired FTP link. This will then display the directory listing of the drive. Clicking on a file link will then initiate an FTP download of the selected file.

Using these links is equivalent to typing an **ftp://** URL into the browser as described in *Using the DT80 FTP Server* (P188). Note however that the web interface links provide read-only (anonymous) access only.

Click on the web browser's Back button to navigate back to the Files page.

Help Page

The Help page provides troubleshooting and help information, and a link to the Technical Support web page on the Datataker website.

There is also a link to the *DT80* User's Manual (PDF format), which is normally pre-loaded onto the *DT80*'s internal file system in the **B:\doc** subdirectory. If the link does not work, verify that the directory and file are present. If required, the manual can be loaded back onto the logger by repeating the firmware upgrade process.

Customising the Classic Interface

This section describes some of the technical features of the *DT80* web interface. These allow advanced users to replace the built-in web interface with a customised web user interface.

Web Application Programming Interface (API)

The *DT80* provides an application programming interface (API) so that you can build custom web pages that can view and display data from the logger. The API consists of a set of **server-side include** (SSI) directives. SSI directives are placed in HTML pages, and evaluated on the logger when the HTML page is requested. HTML pages that contain SSI directives are known as **SHTML** pages, and typically have a **.shtml** file extension.

When an SHTML page is requested, it is scanned by the web server (logger) for these directives. Once found, the logger interprets the directive and performs the required action. The output is then sent as part of the response back to the web browser.

Server-Side Include (SSI) Directives

An **SSI directive** consists of a special sequence of characters which is placed within an HTML page. The format is as follows:

```
<!--#directive attribute="value" attribute="value" ... -->
```

where:

- `<!--#` and `-->` are the opening and closing identifiers that must be specified when applying an SSI directive.
- *directive* is the name of the directive to be executed.
- *attribute* is the name of an **attribute**, and *value* is the value it is set to. Each SSI directive has a set of valid attributes that can be specified to control the operation of the directive. One or more attribute-value pairs can be specified.

For example

```
<!--#echo var = "1CV" -->
```

inserts the SSI directive named `echo`, which contains one attribute `var` whose value is set to `1CV`.

DT80 *SSI Directives*

The *DT80* web server supports five SSI directives, which are summarised in the table below. Each directive requires the indicated attribute to be set. In addition, one or more optional attributes may be included.

Directive	Required Attribute	Function
`echo`	`var`	Inserts the current value of the indicated variable
`channeltable`	`schedule`	Inserts an HTML table containing, for each channel, its schedule, name, most recent value, units and timestamp – similar to the **Channels** page
`measure`	`channel`	Samples the indicated channel (certain channel types only) and inserts the measured value
`reading`	`channel`	Inserts the most recent value of the indicated channel, plus timestamp
`include`	`file` or	Inserts the contents of the indicated text file, specified as a path relative to the document root (`DOC_ROOT` profile setting
	`virtual`	Inserts the contents of the indicated text file, specified as an absolute path

Optional Attributes

One optional attribute is supported, which may be applied to any of the above directives in addition to their standard attribute:

Directive	Attribute	Function
any	`cond`	Evaluate the directive if and only if the indicated condition is true

The following sections discuss each directive in more detail.

#echo Directive

This directive inserts a specific piece of information into the HTML page.

SSI Directive	Description
`<!--#echo var = "D" -->`	Inserts the current date. e.g. `2006/05/02`.
`<!--#echo var = "T" -->`	Inserts the current time. e.g. `11:45:23`.
`<!--#echo var = "dtmodel" -->`	Inserts the model number of the logger. e.g. `DT80`.

`<!--#echo var = "nCV(FFd)" -->`	Inserts the value of channel variable *n*CV. The `(FFd)` part is optional, and specifies the number of decimal places to display (default is one decimal place) e.g. `23.4`.
`<!--#echo var = "nSV(FFd)" -->`	Inserts the value of system variable *n*SV. The `(FFd)` part is optional, and specifies the number of decimal places to display (default is no decimal places) e.g. `23200`
`<!--#echo var = "JobName" -->`	Inserts the name of the current running job (or `no current job` if none). e.g. `MYJOB`.
`<!--#echo var = "SchName(s)" -->`	Inserts the schedule name associated with schedule *s*. e.g. `SchWebA`.
`<!--#echo var = "SchTrigger(s)" -->`	Inserts the trigger string for schedule *s*. e.g. `1S`.
`<!--#echo var = "SchStatus(s)" -->`	Inserts the run status (active/halted) for schedule *s*. e.g. `active`.
`<!--#echo var = "SchLogState(s)" -->`	Inserts the logging state (enabled/disabled) for schedule *s*. e.g. `disabled`.
`<!--#echo var = "SchDataStoreSize(s)" -->`	Inserts the number of the logged data records for schedule *s*. e.g. `2001`.
`<!--#echo var = "SchAlarmStoreSize(s)" -->`	Inserts the number of the logged alarms for schedule *s*. e.g. `2301`.
`<!--#echo var = "SchDataStartTime(s)" -->`	Inserts the timestamp of the earliest logged data record for schedule *s*. e.g. `2006/05/02 14:15:12`.
`<!--#echo var = "SchAlarmStartTime(s)" -->`	Inserts the timestamp of the earliest logged alarm for schedule *s*. e.g. `2006/05/02 15:15:12`.
`<!--#echo var = "SchDataEndTime(s)" -->`	Inserts the timestamp of the latest data record for schedule *s*. e.g. `2006/05/02 11:15:12`.
`<!--#echo var = "SchAlarmEndTime(s)" -->`	Inserts the timestamp of the latest alarm for schedule *s*. e.g. `2006/05/02 14:13:12`.

#channeltable Directive

This directive inserts a table of channel values.

SSI Directive	Description
`<!--#channeltable schedule = "" -->`	Inserts an HTML table containing a header row, plus a row for each defined channel in the current job, excluding working channels and immediate channels. Each row contains the following columns: • schedule identifier (A – K, X) • channel name • most recent value of the channel • units string • time at which most recent measurement was taken
`<!--#channeltable schedule = "s" -->`	As above, but only channels belonging to schedule *s* are included.

Sample HTML output generated by the `#channeltable` directive is as follows:

```
<table class="jdt" cellspacing="0">
 <colgroup>
        <col class="sid"/>
        <col class="sun"/>
        <col class="chv"/>
        <col class="dfu"/>
        <col class="tsp"/>
 </colgroup>
 <thead>
  <tr>
    <th>Schedule</th>
```

```
    <th>Name</th>
    <th>Value</th>
    <th>Units</th>
    <th>Timestamp</th>
  </tr>
 </thead>
 <tbody>
  <tr>
    <td>A</td>
    <td>1V</td>
    <td>1.234</td>
    <td>mV</td>
    <td>2006/04/07 12:12:11</td>
  </tr>
  <tr>
    <td>A</td>
    <td>Geyser Temp</td>
    <td>122.8</td>
    <td>degC</td>
    <td>2006/04/07 12:12:11</td>
  </tr>
  <tr>
    <td>C</td>
    <td>Gravy Press</td>
    <td>69.9</td>
    <td>MPa</td>
    <td>2006/04/05 12:42:01</td>
  </tr>
 </tbody>
</table>
```

Note that the CSS (Cascading Style Sheet) class ids in the table and colgroup tags have been used to style the table. To change the style (colours, spacing, etc.), create another CSS file, reusing the same class ids. By default, the table will be displayed without any styles applied.

#measure Directive

This directive is used to perform a input channel measurement. This is executed in the Immediate schedule and the data gathered is not logged.

SSI Directive	Description
<!--#measure channel = "*chan-def***" -->**	Evaluates the specified *DT80* channel definition, e.g. **2R(4W)** , as an immediate channel, waits for it to complete, then inserts the measured value e.g.: 44.0

#reading Directive

This directive is used to return the most recent reading for the specified channel. The channel is assumed to have been already defined in a schedule in the current job.

SSI Directive	Description
<!--#reading channel = "*chan-name***" -->**	Inserts the most recent reading for the specified existing *DT80* channel, and the time at which the reading was taken. e.g. 2009/03/16 20:41:39.298 19.66 degC

#include Directive

This directive is used to insert the contents of another file into a HTML page.

SSI Directive	Description
<!--#include file = "*rel-file***" -->**	Inserts the contents of the file *rel-file* (specified as a relative path, e.g. **footer.htm**) into the current HTML page.
<!--#include virtual = "*abs-file***" -->**	Inserts the contents of the file *abs-file* (specified as an absolute path, e.g. **b:\events\event.log**) into the current HTML page.

The `#include` directive may be nested, i.e. a file that has been included may itself then include another file, up to a maximum of three levels.

cond Attribute

This attribute may be included by any SSI directive, in addition to its normal attribute. It specifies a **condition** – if the condition is met then the SSI directive is processed, otherwise it is ignored. This provides a way to conditionally include web page elements based on the status of the *DT80*.

condition value	Description
`cond = SchDefined(s)`	Process directive if the specified schedule has been defined
`cond = DataStored(s)`	Process directive if any data have been logged for the specified schedule
`cond = AlarmsStored(s)`	Process directive if any alarms have been logged for the specified schedule

For example:

```
<!--#include file = "schedA.shm" cond = "SchDefined(A)" -->
```

will only include the indicated file if schedule A is defined in the current job.

Building A Custom Web Page

This section provides a brief overview of the process of setting up a custom web page for the *DT80*. It is assumed that the reader has a good working knowledge of HTML and the *DT80*.

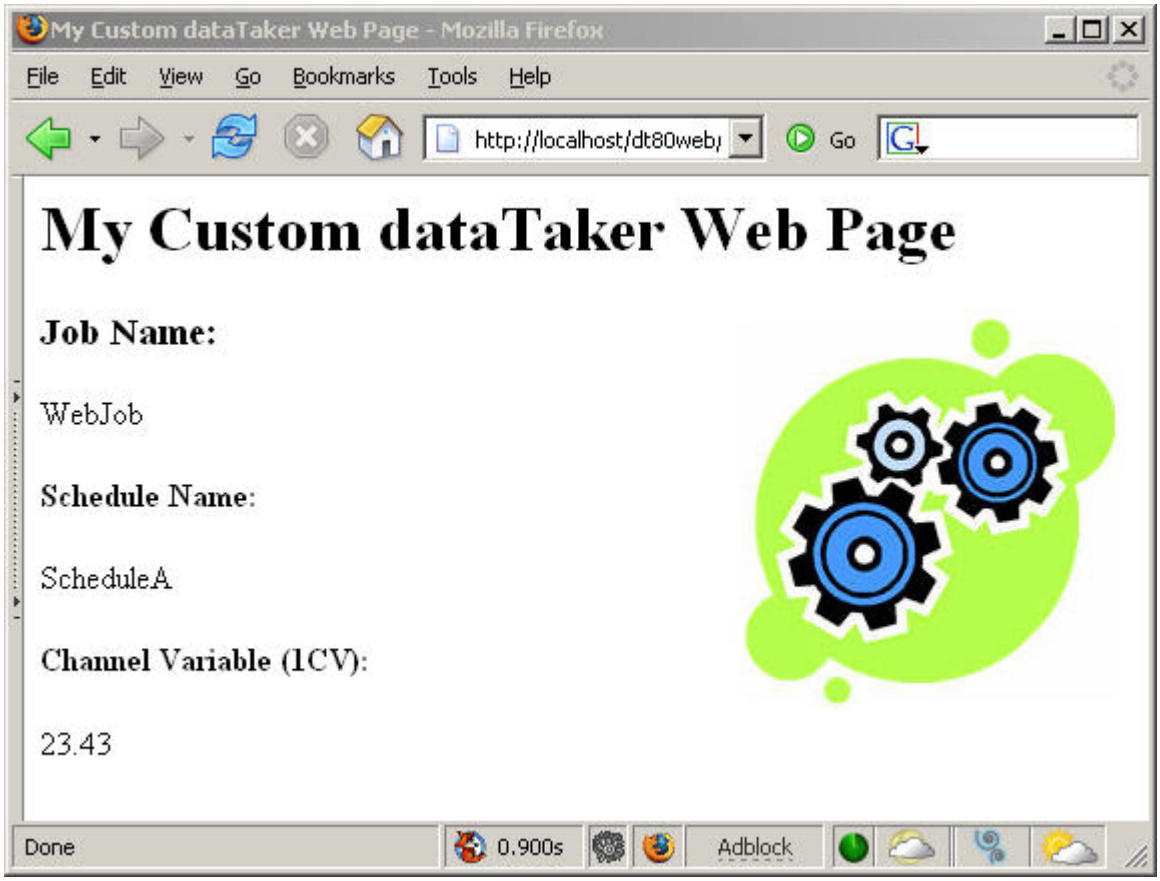
All custom pages will need to be loaded into a directory of your choice on the *DT80*'s internal file system (**B:**).

Creating the SHTML Page

An SHTML page can be created with any HTML or text editor. Let's create a page that is titled "My Custom dataTaker Web Page" that will contain an image and display the following logger data:-

- The current job name
- The name of schedule A for the current job
- The value from channel variable 1

This is what the SHTML page will look like when viewed in a web browser:-



The SHTML mark-up for this page is as follows:

```
<html>
<head>
<title>My Custom dataTaker Web Page</title>
</head>
<body>
<h1>My Custom dataTaker Web Page</h1>
<img src="custom1.jpg" align="right"/>
<h3>Job Name:</h3>
  <!--#echo var = "JobName" -->
<h4>Schedule Name:</h4>
  <!--#echo var = "SchName(A)" -->
<h4>Channel Variable (1CV):</h4>
  <!--#echo var = "1CV" -->
</body>
</html>
```

Notice the SSI directives (red).

Note The SHTML page filename must be saved with the following extensions:- **.shtml**, **.shm** or **.sht**. The SHTML page will not be rendered correctly if these extensions are not used.

Custom Home Page

It is recommended that a central (Home) page is used when building a custom web interface. The Home page can be an HTML or SHTML page. Set the Home page filename to **index.htm** or **index.shm**.

The *DT80* web server will automatically looks for a file with one of these names if the user types just the IP address into their browser (i.e. no filename specified).

Storing the Custom Web Pages

To test the custom web pages they need to be loaded onto the *DT80*'s internal file system.

Connect to the logger's FTP server, specifying the configured username and password – files cannot be written to the file system using the default anonymous username. Then upload the files to a directory on the internal drive, e.g. **B:\www\custom**.

Customising the Built-in Web Interface

As an alternative to creating the web interface from scratch, you can also use the built-in web pages as a starting point and customise them as required.

Start by using an FTP client to copy all files from **b:\www\html** to **b:\www\custom**, then customise as required.

Using the Custom Web Pages

If you loaded the custom web interface into the **b:\www\custom** directory then you can either:

- access it by typing `http://`*ip-addr*`/custom` into the web browser, or defining a bookmark for this URL
- replace the interface selector page (**b:\www\index.html**) with an alternative page which contains a link to your custom interface, or which contains an automatic redirection, e.g.:

```
<html><head>
  <meta http-equiv="Refresh" content="0; url=/custom">
</head><body>
  <a href="/custom">Click here</a>
</body></html>
```

In this way a user which just enters the logger's IP address is automatically directed to the custom interface, but can still access the standard classic interface, for example, by typing `http://`*ip-addr*`/html`.

Automatic Page Refresh

If required, a custom web page can be made to automatically refresh by including the following line within the page header:

```
<html>
  <head>
    <meta http-equiv="Refresh" content="30">
    ...
  </head>
  ...
```

In this example the page will refresh every 30 seconds.

Part J – Modbus Interface

About Modbus

Modbus is a simple communications protocol which is widely used in **SCADA** (supervisory control and data acquisition) systems. Modbus provides an efficient and standardised way to transport digital states and data values between a remote terminal unit (**RTU**) or programmable logic controller (**PLC**) and a supervisory computer.

Servers and Clients

In a Modbus-based SCADA system, each RTU/PLC acts as a Modbus **server**, or **slave**. These servers/slaves listen for and reply to requests from a Modbus **client**, or **master** system. A Modbus client is typically a computer that provides a mimic display, user interface and various data logging and alarm functions.

Modbus can operate using a broad range of communications media. These fall into two main categories:

- a serial connection, typically RS232, RS422 or RS485
- a TCP/IP network, which can use a variety of physical link types e.g. Ethernet, wireless, fibre-optic, serial (PPP)

The *DT80* is capable of operating as a Modbus server; that is, it can act like an RTU or PLC device. This allows the *DT80* to be easily integrated into any Modbus-based SCADA system. No special drivers are required for the client system.

A Modbus client system can directly read or write any *DT80* channel variable (CV) or digital I/O channel.

The *DT80* can also operate as a Modbus client, where it can read data from Modbus sensors in the same way that it reads data from SDI-12 or serial sensors. See *Modbus Channel* *(P290)* for more details.

The remainder of this section describes the operation of the *DT80* as a Modbus server.

In general terms, the procedure for setting up the *DT80* in a Modbus environment is:

1. Establish a physical connection (TCP/IP or serial) between the Modbus client system and the *DT80.*
2. Load a job onto the *DT80* that scans the required channels at the required rates. The job should also load the measured values into channel variables.
3. Configure the client system to poll the Modbus addresses corresponding to the *DT80* CVs and digital I/Os of interest.

Note Even if there is no job loaded, the *DT80*'s Modbus server is still active and the client can query or set any CV or digital channel.

Connecting to a Modbus Network

The *DT80* supports both TCP/IP and serial Modbus networks.

TCP/IP Connection

Up to five Modbus client systems can simultaneously connect to the *DT80* using TCP/IP.

The first step in setting up Modbus over TCP/IP is to establish a working TCP/IP connection between the client system and the *DT80*. This involves assigning an IP address to the *DT80*, along with a couple of other settings, depending on whether Ethernet or PPP is used. See *Ethernet* Communications *(P179)* and *PPP Communications* *(P190)* for more details.

By default, the *DT80*'s TCP/IP Modbus server is always enabled. It will listen for connection requests from client systems which are directed to TCP port 502 (which is the standard port number for Modbus). If required, this port number may be changed using the following *DT80* command:

```
PROFILE MODBUS_SERVER TCPIP_PORT=port
```

where *port* is the desired port number (1-65535).

To disable the *DT80*'s TCP/IP Modbus server, set the port number to zero, i.e.

```
PROFILE MODBUS_SERVER TCPIP_PORT=0
```

Serial Connection

A serial Modbus network has one client (master) system connected to one or more server (slave) devices. Serial networks using the RS485 or RS422 standards support multi-drop, i.e. multiple slaves connected to one master. RS232 or USB can also be used for point-to-point connections (single master and single slave).

Slave devices on a serial Modbus network are identified by an 8-bit **slave address** (1-247). Every slave device on a particular serial network must have a unique address. (Slave addresses are not required on a TCP/IP Modbus network, because the slaves are identified by their IP address.)

The *DT80* can be connected to a serial Modbus network using either the serial sensor port, the host RS232 port, or the USB port.

Serial Sensor Port

The serial sensor port can be used to connect to a Modbus client via a multi-drop (RS422/485) or point-to-point (RS232/422/485) link.

In order to use Modbus on the serial sensor port it is necessary to set the port function, as follows:

```
PROFILE SERSEN_PORT FUNCTION=MODBUS
```

You may also need to configure the baud rate or other serial parameters to suit the system to which you are connecting. Modbus systems commonly use **19200 baud, 8 data bits, 1 stop bit, even parity, no flow control**.

For more details on setting up the port and the possible wiring configurations, see *Serial Sensor Port* (P171).

Note Do not use software flow control (SWFC) on a Modbus serial connection. This is because flow control characters (XON/XOFF) may legitimately appear in Modbus data, and if they do then they will be stripped out. This will cause data errors.

Host RS232 Port

The host RS232 port can be used for a point-to-point serial Modbus connection.

As with the serial sensor port, the port function must be set:

```
PROFILE HOST_PORT FUNCTION=MODBUS
```

along with the serial parameters to match the connected system.

For more details on setting up the port and the possible wiring configurations, see *Host RS-232 Port* (P170).

USB Port

A USB connection can also be used where the client system is within a few metres of the *DT80*.

USB is convenient because you don't have to set serial parameters. The port function does need to be set, however:

```
PROFILE USB_PORT FUNCTION=MODBUS
```

For more details, see *USB Port* (P162).

Slave Address

To enable Modbus operation on the serial sensor port, it is also necessary to set the *DT80*'s slave address. This is done using the following profile setting:

```
PROFILE MODBUS_SERVER SERSEN_ADDRESS=addr
```

where *addr* is the desired address (1-247). Setting the address to zero (which is the default) will disable Modbus on the serial sensor port.

In the same way, Modbus can be enabled on the host RS232 and USB port using:

```
PROFILE MODBUS_SERVER HOST_ADDRESS=addr
PROFILE MODBUS_SERVER USB_ADDRESS=addr
```

Again, the default setting is zero, which means "disabled".

Modbus Registers

The Modbus Data Model

The Modbus protocol defines a simple data model. It specifies that any Modbus slave device contains the following resources:

- an array of single bit **coils** (digital outputs). When setting up a Modbus client application, a particular coil is normally referenced using a 5-digit number in the range 00001-09999, or a 6-digit number 0:00001-0:65536 (depending on the Modbus client implementation). In this manual the 6-digit notation will be used.
- an array of single bit **discrete inputs** (digital inputs), numbered 10001-19999, or 1:00001-1:65536
- an array of 16-bit **input registers**, numbered 30001-39999, or 3:00001-3:65536
- an array of 16-bit **output registers** (a.k.a **holding registers**), numbered 40001-49999, or 4:00001-4:65536

As can be seen, the first digit of the register number indicates the type of register – 0, 1, 3 or 4 for coil, discrete input, input register or output register respectively. This usage is, however, just a convention. This digit is not part of the actual address transmitted in the Modbus message.

A further potential source of confusion is the fact that the actual transmitted address is zero-based, so register number x:00003 is actually transmitted as address 0002.

Note In some Modbus client applications, register numbers are entered using these raw protocol addresses, while in others you specify register numbers including the initial "register type" digit, as described above. The documentation for the particular package should make clear which convention it uses.

The protocol then defines a set of messages which allow the client to:

- read the current value of one or more of the slave's coils, discrete inputs, input registers or output registers
- write to one or more of the slave's coils or output registers.

A given type of Modbus slave device will support some quantity of each type of resource – for example a hypothetical device might support 16 coils, 16 discrete inputs, 4 input registers and no output registers.

Furthermore, it is common for the different register arrays to overlap. In the example device mentioned above, the 16 coils and discrete inputs may actually refer to the same physical hardware – in this case 16 bi-directional I/O pins. So for this slave device, if a client wrote a "1" to coil 0:00007, it would then read the same value back if it did a read from discrete input

1:00007.

Accessing DT80 *Channels via Modbus*

The *DT80* maps blocks of Modbus registers onto certain *DT80* **channels** (channel variables and digital channels), as specified in the following tables. The Modbus client can therefore directly access any of these *DT80* channels by transmitting a request to read or write the associated Modbus register(s).

The first table shows the action taken by the *DT80* in response to requests by the client system to read particular Modbus registers:

Register number as specified in Modbus client application	Type of register to read	Action taken by *DT80*
0:00001-0:01000 1:00001-1:01000	coil 1-1000 discrete 1-1000	returns current state of channel variable 1..1000CV (0 if CV value is 0.0, otherwise 1)
3:00001-3:01000 4:00001-4:01000	input reg 1-1000 output reg 1-1000	returns current value of channel variable 1..1000CV
0:04001-0:04053 1:04001-1:04053	coil 4001-4053 discrete 4001-4053	returns current state of system variable 1..53SV (0 if SV value is 0.0, otherwise 1)
3:04001-3:04053 4:04001-4:04053	input reg 4001-4053 output reg 4001-4053	returns current value of system variable 1..53SV
0:08001-0:08009	coil 8001-8009	returns current state of digital output 1..8DSO or 1RELAY
1:08001-1:08008	discrete 8001-8008	returns current state of digital input 1..8DS
3:08001-3:08008	input reg 8001-8008	returns current state of digital input 1..8DS as a numeric value (0 or 1)
4:08001-4:08009	output reg 8001-8009	returns current state of digital output 1..8DSO or 1RELAY as a numeric value (0 or 1)

The next table shows the action taken by the *DT80* in response to a write request:

Register number as specified in Modbus client application	Type of register to write	Action taken by *DT80*
0:00001-0:01000	coil 1-1000	sets channel variable 1..1000CV to 0.0 or 1.0
4:00001-4:01000	output reg 1-1000	sets channel variable 1..1000CV to the specified value
0:04001-0:04053	coil 4001-4053	sets system variable 1..53SV to 0.0 or 1.0 (writable SVs only)
4:04001-4:04053	output reg 4001-4053	sets system variable 1..53SV to the specified value (writable SVs only)
0:08001-0:08009	coil 8001-8009	sets digital output 1..8DSO or 1RELAY to the specified value
4:08001-4:08009	output reg 8001-8009	sets digital output 1..8DSO or 1RELAY to the specified value (0 if the specified value is 0, otherwise 1)

If the Modbus client attempts to access any register outside the ranges specified above then the *DT80* will return a Modbus error response and ignore the request.

Note that for the DT81/82, Modbus registers x8001-x8004 correspond to channels 1..4DS and 1..4DSO. Accessing registers x:08005-x:08008 will not cause an error, but it will not do anything either, because these channels are not present on the DT81/82. Register x:08009 corresponds to the 1RELAY channel, as with the DT80.

Data Types

Modbus input and output registers are 16 bits wide. The Modbus standard does not, however, define how these bits are to interpreted, other than stating that the most significant byte of a register value is transmitted first ("big endian" format).

By default, the *DT80* interprets a Modbus register as a signed 16-bit integer in the range -32768 to 32767. If a CV or SV's value is outside this range then the associated Modbus register will "saturate", i.e. the value 32767 will be returned if the CV/SV value is greater than 32767, and the value -32768 if the value is less than -32768. Also, the CV/SV value will be rounded to the nearest integer.

There are, however, a number of options for dealing with data values that cannot be represented by a 16-bit integer value:

- the register can be treated as an unsigned 16-bit integer (0-65535)
- the value can be scaled, typically by a power of ten, to give the required precision or range. For example a scaling factor of 100 would permit values in the range -327.68 to 327.67 to be returned.
- multiple registers can be combined to return a single larger value, e.g. a pair of registers could return a 32-bit quantity.

Clearly, both the slave device and the client system must agree on how a given Modbus register is to be interpreted. It is no good if the device encodes the value 40000 as an unsigned 16-bit number (9C40 hexadecimal) but then the client interprets it as a signed number and displays it as -25536.

The only solution is to explicitly configure the required data types on both the slave and the client. For the *DT80*, this is done using the **SETMODBUS** command.

The SETMODBUS Command

By default, all CV values are transferred to and from the *DT80* as signed 16-bit integers, with no scaling factor. The **SETMODBUS** command is used to specify alternative data types and scaling factors.

The format of the command is as follows:

```
SETMODBUS channels format scaling
```

where:

- *channels* specifies a single channel variable, or a range (e.g. `1CV` or `20..29CV`)
- *scaling* is an optional floating point scaling factor by which the channel value will be multiplied before being returned. Conversely, when the client writes a value, it will be divided by the scaling factor before being written to the CV.
- *format* is an optional code that specifies the data type, as follows:

Format code	Data type	Comments
`MBI`	signed 16-bit integer	Default setting. Returns -32768 or 32767 if the scaled return value is outside the valid range.
`MBU`	unsigned 16-bit integer	Returns 0 or 65535 if the scaled return value is outside the valid range.
`MBLS` (or `MBL`)	signed 32-bit integer, standard word order	Upper 16 bits of *n*CV are returned in Modbus register *n*. Lower 16 bits are returned in register *n*+1. Returns -2,147,483,648 or 2,147,483,647 if the scaled return value is outside the valid range.
`MBLR`	signed 32-bit integer, reversed word order	Lower 16 bits of *n*CV are returned in Modbus register *n*. Upper 16 bits are returned in register *n*+1. Returns -2,147,483,648 or 2,147,483,647 if the scaled return value is outside the valid range.
`MBFS`	32-bit floating point, standard word order	Returned as a single precision IEEE-754 floating point number. Upper 16 bits of *n*CV are returned in Modbus register *n*. Lower 16 bits are returned in register *n*+1.
`MBFR` (or `MBF`)	32-bit floating point, reversed word order	Returned as a single precision IEEE-754 floating point number. Lower 16 bits of *n*CV are returned in Modbus register *n*. Upper 16 bits are returned in register *n*+1.

If *format* and *scaling* are not specified, the current settings for the indicated range of CVs are displayed.

Any number of these `SETMODBUS` commands can be issued (typically at the start of the *DT80* job) to configure the required channels.

Note The `SETMODBUS` command only supports channel variables. However some system variables may have values outside the range -32768 to 32767, or may have a fractional part. Such SVs can be assigned to a CV, for which an appropriate data type and/or scaling factor can then be set, e.g.:

```
SETMODBUS 1CV MBLS
3SV(=1CV)
```

Example

This example illustrates some of the technicalities relating to Modbus transfers.

Consider the following job:

```
BEGIN"PERCY"
SETMODBUS 7CV MBF
SETMODBUS 9..10CV MBU 100
SETMODBUS 11CV MBL
7CV=23.91  8CV=42  9CV=490.22  10CV=921.0  11CV=75535.9
END
```

If a Modbus client then requests input registers 3:00007-3:00012 it will receive the following raw data:

Register	Value (hex / decimal)	Comments
3:00007	47AE	The 32-bit value 41BF47AE is the IEEE754 representation of 23.91
3:00008	41BF	
3:00009	BF7E / 49022	490.22 multiplied by scaling factor (100)
3:00010	FFFF / 65535	overflow: 921.0 x 100 = 92100 is too big for an unsigned 16-bit integer
3:00011	0001 / 1	The 32-bit value 00012710 equals 75536 decimal
3:00012	2710 / 10000	

To make sense of this, the client software must support the 32-bit data formats used by the *DT80*, and it must be told the data type of each register (or register pair).

Note Be aware that for 32-bit data types, the word order (i.e. whether the upper or lower 16 bits comes first) is not proscribed by the Modbus standard, so naturally both orderings are widely used. Most client software can be configured to support either ordering.

Note that in this example 7CV and 11CV are spread across two registers apiece (3:00007-8 and 3:00011-12 respectively), which makes channel variables 8CV and 12CV effectively inaccessible via Modbus. They can still be used in the program (e.g. setting `8CV=42` in the above program is perfectly OK and won't interfere with 7CV); it's just that they cannot (easily) be accessed by a Modbus client.

Note also that some Modbus clients require that all 32-bit register pairs start on an odd-numbered register. That is, you can return a 32-bit value using registers 30001-30002, but not using registers 30002-30003.

Putting It All Together

In this example, a greenhouse is monitored by a DT80. Three thermocouples on analog inputs **1-3** monitor the temperature at various points. The DT80 is required to log the temperatures every 15s and switch on an extractor fan (by setting digital output **1D** low) if any of the temperatures exceed a programmable setpoint. A sensor attached to the fan produces a voltage proportional to fan speed (1.25mV/rpm) and this is fed into analog input **4**. Digital output **2D** is connected to a watering system valve.

The DT80 is connected to an Ethernet network. In a central office an operator runs a Modbus-capable SCADA package. She wants to be able to:

- check current temperatures
- set the current extractor fan setpoint
- check the status of the extractor fan (fan RPM and state of control output)
- switch the watering system on or off
- check how many data and alarm records have been logged

The following sections discuss how this might be achieved.

DT80 Configuration

It is assumed that the *DT80*'s Ethernet connection has already been set up. This can be verified by entering its IP address into *DeTransfer* or a web browser and checking that the *DT80*'s command or web interface is accessible. If you cannot connect to these services then you probably won't be able to connect to the Modbus server either. See *Ethernet* Communications *(P179)* for more information.

Once TCP/IP connectivity has been established, a suitable *DT80* job can be entered:

```
BEGIN"GERANIUM"
SETMODBUS 1..4CV MBI 10 ' temperatures & setpoint
SETMODBUS 5..7CV MBL 1  ' logged data,alarm recs (32 bit)
SETMODBUS 9CV    MBI 1  ' fan RPM
4CV(W)=30.0 ' default setpoint
' update every 15 sec
RA(DATA:30D,ALARMS:500KB)15S
 1TK(NR,=1CV)
 2TK(NR,=2CV)
 3TK(NR,=3CV)
 ' set 10CV=1 if at least one temp over limit
 ' set 11CV=1 if all temps under limit
 ' allow +/- 1 degC hysteresis
 10CV(W)=(1CV>4CV+1)OR(2CV>4CV+1)OR(3CV>4CV+1)
 11CV(W)=(1CV<4CV-1)AND(2CV<4CV-1)AND(3CV<4CV-1)
 ALARM1(10CV>.5)"Temp>?4 Fan ON^M"{1DSO=0}
 ALARM2(11CV>.5)"Fan OFF^M"{1DSO=1}
 32SV(W,=5CV)  ' num logged data recs for sched A
 33SV(W,=7CV)  ' num logged alarm recs for sched A
 4V(W,0.8,=9CV)  ' fan speed 1.25mV/rpm
LOGONA
END
```

This job sets up the following CVs for access by the Modbus client:

- **1CV**, **2CV** and **3CV** contain the three measured temperatures. A scaling factor of 10.0 is applied so that it can be returned with one decimal place (range -3276.8 to +3276.7)
- **4CV** is designed to be accessed as an output register, i.e. the Modbus client writes to it. This channel variable is used as the temperature setpoint, so it is scaled in the same way as the other temperature CVs.
- **5CV** and **7CV** return the number of logged data and alarm records for the main A schedule. In this example the store file size is relatively large (30 days data @ 15s scans), so the number of logged records may exceed the capacity of a single 16-bit register. They are therefore defined as 32-bit long integers (**MBL**). (Channel variables **6CV** and **8CV** have been skipped because their associated Modbus registers are used for returning the 32-bit 5CV and 7CV values.)
- **9CV** returns the fan speed in RPM. A standard 16-bit integer is OK here. (The **SETMODBUS** command for this CV could have been omitted because the values it is setting are the default values.)

Notice that all Modbus-accessible CVs have been grouped into one contiguous block. This is not essential, but it will improve the efficiency of the Modbus link because the client can request all relevant CVs in one command.

The digital channels of interest are **1DSO** (fan control) and **2DSO** (watering system). Since the Modbus client can access these channels directly, there is no need to include them in the *DT80* job.

One final point is that because all relevant data are returned by Modbus, there is no point having the *DT80* return real time data via its standard command interface – it would just clutter the screen if the operator ever needed to connect to the *DT80*

using DeTransfer. All channels are therefore set to "working"' (**W**) or "no return" (**NR**) channels.

Modbus Client Configuration

It is now necessary to configure the SCADA software package to suit the *DT80* channel usage described above. This is highly application dependent but in very general terms the steps involved will typically include:

- configuring communications details
- designing a mimic screen incorporating the required measurement and control fields
- associating each element of the mimic with the correct Modbus register address

So in this case the first step might be to select the software package's "generic PLC" device driver and then create a "DT80" device instance. As a minimum, the *DT80*'s IP address would need to be entered here. If the driver or application provides a "test" facility, you may at this point be able to try manually reading and writing specific Modbus registers.

The mimic screen for this application might consist of:

- three thermometer displays showing the measured temperatures
- an entry field where the operator can set the desired setpoint
- two numeric indicators showing number of logged data and alarm records
- a fan icon with on/off and RPM indicators
- a button to turn the watering system on or off.

The final step would typically then be to edit the properties of each control and indicator to specify their behaviour. This would generally mean specifying:

- which slave device to use. This may involve selecting the *DT80*'s "device instance" from a list of connected Modbus slave devices.
- the Modbus register number
- the data type (signed or unsigned or floating point, 16 or 32 bits, byte/word ordering)
- the scaling factor. This is often presented as a **span**, similar to a *DT80* span *(P60)*. That is, you specify the "device range" (min/max returned value) and the corresponding "display range" (min/max value to display) – which then creates a linear scaling curve.
- the scan rate (how often to read/write the value from/to the *DT80*)
- other details such as units.

So the setup for this application might be something like:

Mimic Element	Modbus Reg	Data Type	Device Range	Display Range	Units	Comments
"temp1"	3:00001	signed 16-bit	-3276 to 3276	-327.6 to 327.6	degC	1CV (input reg)
"temp2"	3:00002	signed 16-bit	-3276 to 3276	-327.6 to 327.6	degC	2CV (input reg)
"temp3"	3:00003	signed 16-bit	-3276 to 3276	-327.6 to 327.6	degC	3CV (input reg)
"setpt"	4:00004	signed 16-bit	-3276 to 3276	-327.6 to 327.6	degC	4CV (output reg)
"num_data"	3:00005	signed 32-bit, MSW first	-1 to 1000000	-1 to 1000000	recs	5CV (input reg)
"num_alm"	3:00007	signed 32-bit, MSW first	-1 to 1000000	-1 to 1000000	recs	7CV (input reg)
"fan_rpm"	3:00009	signed 16-bit	0 to 32767	0 to 32767	rpm	9CV (input reg)
"fan_state"	0:08001	n/a	n/a	n/a	on/off	1DSO (coil)
"water"	0:08002	n/a	n/a	n/a	on/off	2DSO (coil)

Notice how input register numbers are prefixed by "3", output registers by "4" and coils (output bits) by "0".

Note Different Modbus client packages may specify Modbus register numbers in different ways. For example, register 3:0001 may be specified as "30001", "300001", "input register 0001", or "input register, address 0000". In all cases the message transmitted to the *DT80* is identical; the difference is just in how you enter it into the software.

Troubleshooting

Setting **P56=4** will enable the output of diagnostic messages which allow you to see received and transmitted Modbus messages as they occur. For example:

```
P56=4
Modbus RX <192.168.1.60:1168: 00000000000601 0400000008 (12)
Modbus TX >192.168.1.60:1168: 00000000001301 0410000000000000000000000000000000000000 (25)
Modbus RX <192.168.1.60:1168: 00010000000601 0400000008 (12)
Modbus TX >192.168.1.60:1168: 00010000001301 0410000000000000000000000000000000000000 (25)
Modbus RX <HOST: 01 0400000008f1cc (8)
Modbus TX >HOST: 01 0410000000000000000000000000000000552c (21)
```

This shows a message received from a Modbus client at IP address 192.168.1.60 (port 1168) which has total length of 12 bytes. The data is shown in hexadecimal form. The first part is the TCP/IP-specific header, which comprises: a transaction identifier (`0000`, used to match up requests and replies), a protocol identifier (`0000` indicates Modbus), the number of following bytes (`0006`) and the slave address (`01` – not applicable for TCP/IP). The actual Modbus frame follows: `04` for "read input registers" function code, starting address `0000` and length `0008`. This is therefore a request to read the values of 1CV to 8CV.

The *DT80* then replies with the same function code (`04`), the byte count (`10`), and 8 x 16-bit data values (all zero in this case).

This exchange is then repeated; notice that the client has incremented the transaction identifier, which is now `0001`.

A serial Modbus message is then received on the host port, addressed to slave ID `01`. Again, this is a request to read 1CV to 8CV. Note that serial Modbus also includes a checksum on the end (`f1cc`).

Assuming that the *DT80* has been configured for address 1, using

```
PROFILE MODBUS_SERVER HOST_ADDRESS=1
```

then it will respond to the message as shown.

Part K – Communications

Overview

The *DT80* is very flexible and provides many communications options. To understand how these fit together and what combinations are possible, it is helpful to think of communications in terms of the following hierarchy:

- **Clients** are software programs (e.g. a web browser, or the job running on the logger) that initiate communications to or from the *DT80*.
- These clients use **services** that are provided by the logger (e.g. web server, command interface).
- The services are in turn implemented using particular communications **protocols** (e.g. FTP, Modbus).
- These protocols cause data to be physically transmitted using one of the *DT80*'s physical communications **ports** (e.g. Ethernet port, USB port)
- The data travels via a **physical connection** to one of these ports (e.g. USB cable, Ethernet LAN connection)
- Finally, at the other end of the physical connection is the physical **device** with which the *DT80* is communicating (e.g. PC, serial sensor)

This is illustrated in *Figure 56* (P160), and described further below. Later sections will explain common usage scenarios in more detail.

Services

The *DT80* provides eight basic **services** through which it can communicate with a host computer or other device:

- a **command interface**, to which a host computer sends ASCII commands and from which it receives ASCII data and other responses. All of the various commands and responses described in this manual are sent to the *DT80* via its command interface. See *The Command Interface* (P161).
- a **web interface** (*dEX*). This allows the *DT80* to be monitored and configured remotely using a standard web browser, such as Microsoft Internet Explorer. See *Web Interface* (P114).
- an **FTP server**. The File Transfer Protocol is a standard TCP/IP based protocol, which allows files to be efficiently transferred between the *DT80*'s file system and that of a host computer. These transfers are initiated by the host (client) computer. See *Using the DT80 FTP Server* (P188).
- an **FTP client**. This allows transfer of data between the *DT80*'s file system and that of a host computer, initiated by the current job on the *DT80*. See *Retrieving Logged Data* (P90).
- a **Modbus server**. This allows the *DT80* to be monitored and controlled by a Modbus client system (typically a SCADA package). See *Modbus* Interface (P151).
- a **Modbus client**. This allows Modbus sensors to be polled under the control of the current job on the *DT80*. See *Modbus Channel* (P290).
- an **SDI-12 data recorder** function. This allows SDI-12 sensors to be polled under the control of the current job on the *DT80*. See *SDI-12 Channel* (P272).
- a **generic serial** facility, where data strings are transferred to and from a PC or serial sensor device under the control of the current job on the *DT80*. See *Generic Serial Channel* (P277).

Protocols

A **communications protocol** is a set of rules governing what is transmitted over a communications link. The *DT80* implements certain communications protocols, which are used to provide the services listed above.

There are two classes of protocols:

- **serial protocols**, which operate on the *DT80*'s serial ports (USB, host, serial sensor)
- **TCP/IP network protocols**, which require a TCP/IP connection between the host computer and the *DT80*. (The process of establishing a TCP/IP connection will be discussed below.)

Serial Protocols

The *DT80*'s serial ports (USB, host, serial sensor) all support the following serial protocols:

- the **serial command interface** protocol. This consists simply of *DT80* commands and responses transmitted directly over a point-to-point serial connection.
- the **serial Modbus** protocol. The *DT80* only implements the slave (server) side of this protocol.
- the **generic serial** protocol.

- **PPP** (point to point protocol), which allows a TCP/IP connection to be established over a serial link. This then provides similar capabilities to the Ethernet port, i.e. all TCP/IP-based protocols can then operate using this link.

  The *DT80* implements a PPP server only. A PPP client (e.g. a PC) can establish a PPP connection to the DT80, but the *DT80* cannot establish a PPP connection with a PPP server (e.g. and Internet service provider).

Note that each serial port can only support one of these protocols at a time.

The **SDI-12** protocol is only supported on the SDI-12 capable I/O terminals (**5D-8D**).

TCP/IP Protocols

TCP/IP based protocols are used to communicate between devices that have an **IP address** set (IP = Internet Protocol). An IP address can be assigned to the *DT80*'s Ethernet port, and to any serial port on which a PPP connection has been established.

The *DT80* supports the following TCP/IP protocols:

- the **network command interface** protocol. This consists simply of *DT80* commands and responses transmitted via TCP port 7700.
- the **network Modbus** protocol (TCP port 502), which a SCADA system uses to access the *DT80*'s Modbus server, and the *DT80* uses to access other Modbus devices.
- the **Hypertext Transfer Protocol (HTTP)** (TCP port 80), used for accessing the *DT80*'s web server.
- the **File Transfer Protocol (FTP)** (TCP port 21). This allows files to be transferred between the *DT80* and another computer.

Multiple protocols can be active on the one physical port at the same time.

Physical Ports

The *DT80* has the following physical communications ports:

- **Ethernet** port – supports TCP/IP protocols
- **USB** port – supports serial protocols (and TCP/IP protocols if PPP is used) (not DT82)
- **host** RS232 port – supports serial protocols (and TCP/IP protocols if PPP is used)
- **serial sensor** port (RS232/422/485) – supports serial protocols (and TCP/IP protocols if PPP is used) (not DT81/82E)
- 4 **SDI-12** ports (**5D-8D**) (1 port for DT81/82E: **4D**, none for DT82I) – supports SDI-12 protocol only

About the Communications Diagram

Figure 56 *(P160)* shows the various communications options available on the *DT80*. The diagram may appear slightly intimidating; the following notes may help in deciphering what it is trying to indicate.

- The outer dashed line represents the boundary of the *DT80* itself. The physical comms ports (blue boxes) therefore appear on the boundary between "inside" and "outside".
- The green ellipses represent clients – things which initiate communications actions. Clients are generally software applications. As can be seen, most of these are external to the *DT80* (i.e. running on some external computer system), the exception being the *DT80*'s current job.
- The pink boxes at the bottom represent physical devices connected to the *DT80*, and the lines connecting these to the *DT80*'s communications ports (blue) represent physical communications links.
- All other boxes are not physical things, but rather they represent aspects of the *DT80*'s functionality. Broadly speaking, the lines connecting these boxes indicate a "uses" relationship. For example, a "SCADA system" client uses the *DT80*'s "Modbus server" service, which may then use the "serial Modbus" protocol, which may then use the USB port.
- Where multiple lines converge on a single point (e.g. on either side of the physical port boxes), this indicates "choose one". For example, the USB port can use either the PPP protocol, or the serial Modbus protocol, or the serial command protocol, or the generic serial protocol. It cannot use more than one protocol at the same time. Similarly, the Ethernet port can physically connect either directly to a PC (using a "crossover" cable), or to a local or wide area network (LAN/WAN) by connecting to a network switch or hub.
- Where multiple lines join to a box but not at a single point, this implies that simultaneous operation is possible. For example, the serial command protocol can operate on both the USB and host RS232 ports at the same time if you wish. Likewise, any or all of the TCP/IP based protocols can be used over the Ethernet port at the same time.

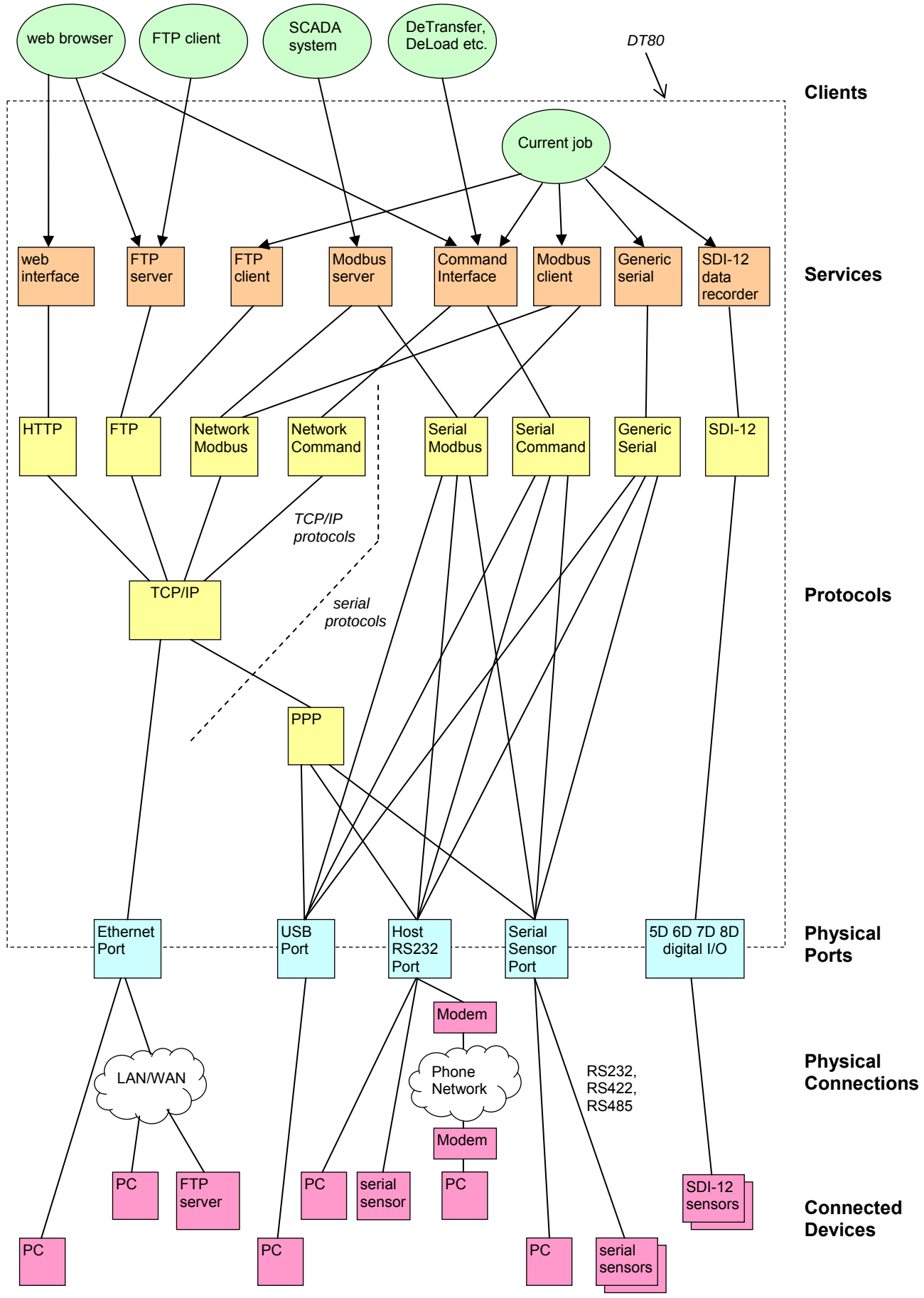


Figure 56: DT80 *communications options*

The Command Interface

Connecting to the Command Interface

As shown in *Figure 56* *(P160)*, the command interface can operate over a serial link ("serial command" protocol), and/or over a TCP/IP network ("network command" protocol). In other words, you can send commands from a computer to the *DT80* via:

- a direct connection to the USB port *(P162)*
- a direct RS232 connection to the host RS232 or serial sensor port, using a crossover ("null modem") cable *(P174*
- a fixed or dial-up modem, which is connected to the RS232 port *(P174)*.
- a TCP/IP network, which is connected to the Ethernet port *(P179)*.
- a point-to-point TCP/IP connection, using PPP. This may use the USB, host RS232 (with or without modem) or serial sensor port.

Arbitration

The *DT80*'s command interface may be set up to operate over more than one type of communications link at the same time.. In this situation, the *DT80* automatically switches between each link as required, responding back through the link from which the most recent communication was received.

You can therefore switch to a new comms interface at any time, simply by sending a *DT80* command (or just a carriage return character) via that interface.

Broadcasting Data

Up to ten different computers can be simultaneously "connected" to the *DT80* command interface using TCP/IP.

Although there can only be one active command interface connection at any one time, it is possible for the *DT80* to "broadcast" data to a number of computers simultaneously.

All output text generated by the *DT80* (command echoes, messages, returned/unloaded data etc.) is sent to:

- the active command interface connection (which may be RS232, USB or TCP/IP), and
- all currently open TCP/IP connections (if any)

In this way a number of computers can be connected to the *DT80* via a TCP/IP network and passively "listen" to the stream of returned data generated by the *DT80*.

Command Interface Operation

Characters received via the command interface are **buffered** until a carriage return (CR) character is received. This buffer can hold 255 characters, so this is the maximum line length that can be sent to the *DT80*.

Once a CR is received, the *DT80* will:

1. **wait** until any currently executing schedule completes
2. **echo** the received command line (after converting it to uppercase). Command echo can be disabled using the **/e** switch command.
3. **process** the command.
4. output the *DT80>* **prompt**, to indicate it is ready for the next command.

Note that it is not necessary to wait until a command completes before sending the next command, as the *DT80* provides additional buffering for subsequent command lines. Each type of comms channel provides some form of automatic **flow control** to ensure that these buffers do not overflow when a large number of command lines are sent at once.

Detecting *DT80* Presence

Host software can detect the presence of a *DT80* by sending a DEL character (ASCII 127). If this character is received at any time, the *DT80* will respond with << followed by CR LF. The DEL character is always recognised and responded to, even if a password has been applied (see below).

Password Protection

To reduce the possibility of unauthorised access to the *DT80*'s command interface, you can configure a **password**, so that communication is only possible after the password is entered.

Setting and Removing the Command Interface Password

Set a password by sending

PASSWORD="*password***"**

to the *DT80*. *password* can be any text string of up to 10 case-sensitive characters.

Remove a password by sending

PASSWORD=""

Note The password is cleared if the *DT80* performs a hardware or **HRESET** reset.

Accessing Password-Protected Command Interface

To establish communication at any time, simply send the password followed by a carriage return. If the password is correct, the *DT80* responds with `Accepted` and opens the comms port.

The port stays open until you send the **SIGNOFF** command, or while there is comms activity. If there is no communication for a period of time defined by P14 (default is 600 seconds), the port will time out and close.

Is the Command Interface Protected?

Send the command

PASSWORD

to determine if a command interface password has been set. The *DT80* responds with `1` if a password has been set, otherwise `0`.

USB Port

Configuring the USB Port

USB is much simpler to configure than RS232 because the baud rate, framing and flow control settings are all fixed by the USB standard. The *DT80*'s USB interface always operates at the standard USB "full speed" rate (12Mbps).

Note that the USB port supports direct connections only. USB modems are not supported.

The only setting that can be specified is the port function. This is set using the **PROFILE** command (see *Profile Settings (P204)*), e.g.

PROFILE USB_PORT FUNCTION=MODBUS.

The possible settings for the USB port **FUNCTION** parameter are:

- **COMMAND** (default) – the port accepts *DT80* commands sent directly over the serial interface. The port will automatically switch to PPP mode if an incoming PPP connection is detected. When the PPP connection is closed the port will go back to accepting direct commands.
- **PPP** – the port accepts PPP connections only.
- **SERIAL** – data transmission and reception is controlled by the current job, using the **3SERIAL** channel.
- **MODBUS** – the port receives and processes incoming serial Modbus requests.
- **MODBUS_MASTER** – the port is used for polling a Modbus sensor device, as specified in the current job using the **3MODBUS** channel.
- **DISABLE** – the port is disabled. This setting reduces power consumption.

The remainder of this section will assume that the USB port function has been set to **COMMAND**.

About DtUsb

In order to use the *DT80*'s USB port, it is first necessary to install the dataTaker ***DtUsb*** driver software on your computer.

Once *DtUsb* is installed, it provides two separate "interfaces" to allow application programs to communicate with the *DT80*.over USB:

- a TCP/IP interface, which allows full access to all of the *DT80*'s TCP/IP services, including the *dEX* web interface
- a secondary "virtual COM port" interface, where the USB port appears as a standard serial COM port. This allows applications such as DeTransfer to establish a serial connection to the logger over USB in the same way that they would using RS232 (although note that DeTransfer can also perform most of its functions over a TCP/IP interface)

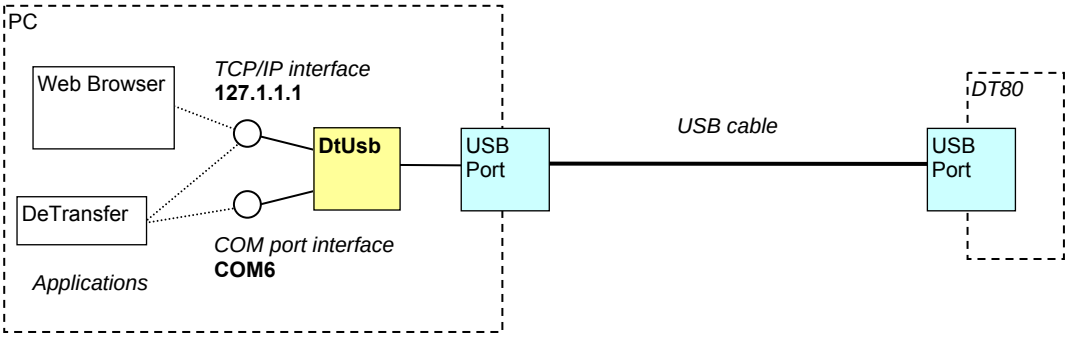


Figure 57: Using DtUsb to communicate with the DT80 *over USB*

Note that only one of these interfaces can be active at any one time.

By default, the TCP/IP interface will be active, so when the logger USB cable is plugged in, the logger will then become visible at IP address 127.1.1.1 (this address may vary).

If, however, you shut down the TCP/IP part of *DtUsb* then the logger's virtual COM port (shown as COM6 in the diagram) will become available.

In most cases, it is simpler and more flexible to perform all communications via the TCP/IP interface.

Installing DtUsb

DtUsb is supplied on the dataTaker Resource CD shipped with your logger. It may also be downloaded from the dataTaker web site, **www.datataker.com**.

Note It is recommended that you install *DtUsb* before connecting the *DT80's* USB cable to the computer.

System Requirements

DtUsb requires Windows XP or later. It also requires Microsoft .NET Version 2.0 or later. If you have Windows Vista or later then .NET should already be installed; it may also have been installed by another application on your computer. The *DtUsb* installation program will check whether .NET is present during installation.

You will need administrator rights for your computer in order to install *DtUsb.* Once it is installed, a normal user account can be used.

Installation Procedure

The following procedure will install *DtUsb* on to your computer. Do not connect the *DT80*'s USB cable to the computer until instructed to do so.

Note Depending on your Windows version, you may receive various prompts during the *DtUsb* installation processes requesting your permission to run software published by Thermo Fisher Scientific. Answer **Yes** or **Continue** to these.

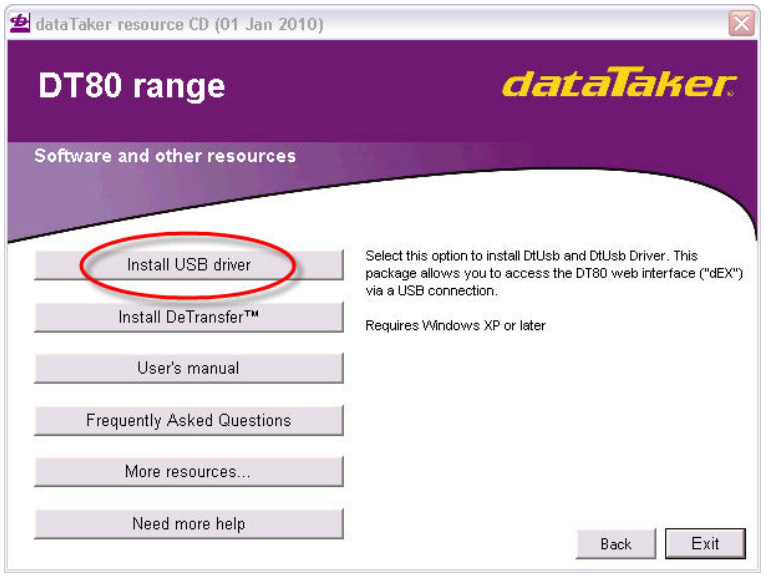
1. Ensure that you are logged in to your computer as an administrator.
2. Insert the dataTaker Resource CD. The CD menu program (see below) should start automatically; if it doesn't then use Windows Explorer to locate **DtAutoRun.exe** on the CD and double click it.

   If you are installing from an installation package downloaded from the dataTaker website then save the downloaded package and double click to run it. Skip to Step 5.

3. Select **DT80 range...**

dataTaker resource CD (01 Jan 2010)
dataTaker resource CD
dataTaker
Select your dataTaker data logger or accessory
DT80 range...
DT800...
CANgate...
Modems...
www.datataker.com
Select this option to access the software, tutorials and other useful information for your dataTaker DT80, DT80G, DT81, DT85G or DT85 data logger.
Exit

4. Select **Install USB driver**


dataTaker resource CD (01 Jan 2010)
DT80 range
dataTaker
Software and other resources
Install USB driver
Install DeTransfer™
User's manual
Frequently Asked Questions
More resources...
Need more help
Select this option to install DtUsb and DtUsb Driver. This package allows you to access the DT80 web interface ("dEX") via a USB connection.
Requires Windows XP or later
Back
Exit

5. *DtUsb* actually consists of two parts: *DtUsb Driver* (the low level "plug and play" USB driver) and *DtUsb* (which provides the TCP/IP interface). Both of these will now be installed, starting with *DtUsb Driver*.

   Click **Next**

DTUSB Driver Installer
dataTaker
Welcome to the DTUSB Driver Installer!
This wizard will walk you through the process of installing or updating the Datataker USB driver.
To continue, click Next.
< Back
Next >
Cancel

6. After the drivers have been copied to your computer a confirmation screen similar to the following will be displayed. Check that two green ticks are displayed.

   Click **Finish**

DTUSB Driver Installer
dataTaker
DTUSB Driver Installer wizard completed
The device driver installation wizard did not update any of your software for your hardware devices because it was not better than the software you currently have installed.
Driver Name
Status
Datataker DT8x/FTDI U...
Ready to use
Datataker DT8x/FTDI U...
Ready to use
< Back
Finish
Cancel

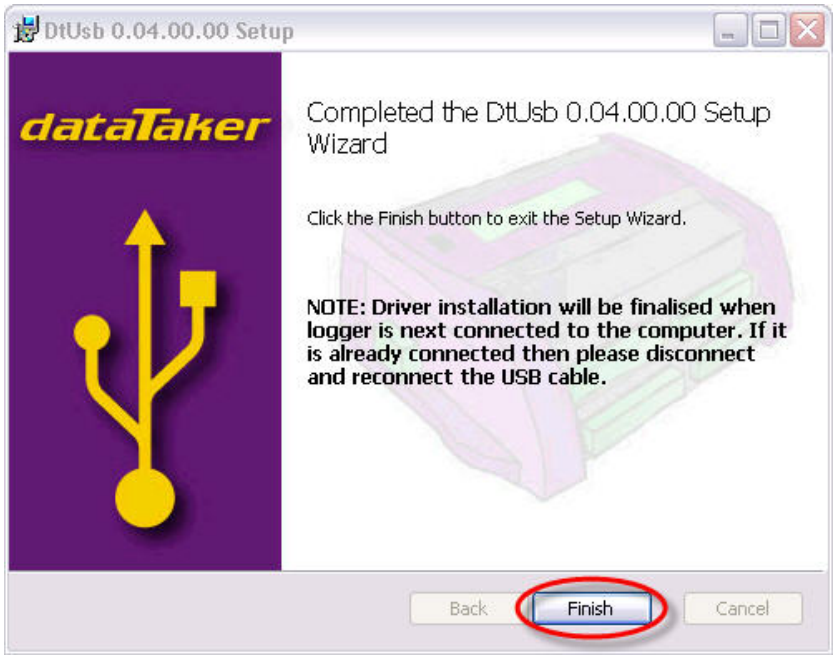
7. The *DtUsb* installer will now start. If you are installing from the CD and do not have .NET 2.0 or later on your computer it will now be installed (after you accept the Microsoft license agreement), then the *DtUsb* installer will continue. (If you are using a downloaded *DtUsb* package then the installer will terminate if .NET is not present and you will need to obtain it from the Microsoft website.)

   Accept the *DtUsb* license agreement and click **Install**

DtUsb 0.04.00.00 Setup
dataTaker
Please read the DtUsb 0.04.00.00 License Agreement
End User License Agreement
IMPORTANT
YOU SHOULD CAREFULLY READ THE FOLLOWING TERMS, CONDITIONS AND RESTRICTIONS SET FORTH IN THIS END USER LICENSE AGREEMENT ("EULA") BEFORE INSTALLATION AND USE OF THE "DTUSB" SOFTWARE ("PROGRAMS"). INSTALLATION OR USE OF SUCH PROGRAMS SHALL BE DEEMED TO CONFIRM YOUR ACCEPTANCE OF THE TERMS, CONDITIONS AND RESTRICTIONS SET FORTH IN THIS EULA.
IF YOU DO NOT AGREE WITH AND ACCEPT THE TERMS, CONDITIONS AND RESTRICTIONS SET FORTH IN THIS EULA, YOU SHOULD PROMPTLY RETURN ALL SUCH SOFTWARE AND DATATAKER DT80 RANGE DATA LOGGER PRODUCTS SUPPLIED WITH THE SOFTWARE TO THERMO FISHER
I accept the terms in the License Agreement
Print
Back
Install
Cancel

8. Once *DtUsb* has been installed a confirmation screen will be displayed.

   Click **Finish**


DtUsb 0.04.00.00 Setup
dataTaker
Completed the DtUsb 0.04.00.00 Setup Wizard
Click the Finish button to exit the Setup Wizard.
NOTE: Driver installation will be finalised when logger is next connected to the computer. If it is already connected then please disconnect and reconnect the USB cable.
Back
Finish
Cancel

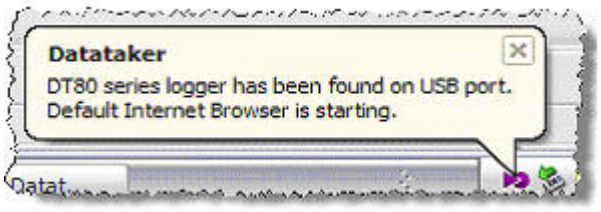
9. Now connect the *DT80* to the computer using the USB cable. This will trigger the Windows "plug and play" process to complete driver installation.

   You may notice a flurry of activity in the system tray area. The actual sequence of events depends on your operating system.

   - For **Windows XP**, the drivers that you pre-installed in Step 5 will be automatically installed with a minimum of fuss. A couple of "New hardware found" balloon messages will appear, then finally it should say "Your new hardware is ready to use"
   - For **Windows Vista**, you will be asked whether you want to locate and install driver software, or do nothing. Specify that you do want to locate and install drivers. It will then search for the drivers on Windows Update. Assuming you have a working internet connection, it should find the drivers there and install them. If not then the Windows Update search will time out and it will install the drivers that you pre-installed in Step 5. Eventually Windows should report that "Your new hardware is ready to use".
   - For **Windows 7**, the initial prompt will be skipped and it will go straight to Windows Update. As with Vista, if this is successful then it will install the drivers it finds there, otherwise it will eventually time out and use the pre-installed drivers.

   Note that *DtUsb Driver* actually consists of two separate Windows drivers – a USB driver and a virtual COM port driver. You may therefore see the above "plug and play" process occur twice, once for each driver.

10. Once the two parts of *DtUsb Driver* have been installed, *DtUsb* should notice that a logger has been connected. A new icon should appear in the system tray.



11. *DtUsb* will now automatically launch your default web browser and display the *dEX* home page.
12. If desired, you may now log off as administrator and log in as a normal user. *DtUsb* will be loaded automatically when any user logs in to the computer.

Using DtUsb

DtUsb is a background process, which is started automatically when any user logs in to the computer. It will, however, do nothing until a *DT80* is connected via USB.

When a *DT80* is connected, *DtUsb* will:

- establish a PPP connection to the logger over the USB link (PPP is a protocol that allows TCP/IP traffic to be passed over a point-to-point serial link)
- provide a local IP address, typically 127.1.1.1, which effectively becomes the *DT80*'s IP address.
- display the purple icon in the task bar, which will remain visible whilst the logger is connected
- optionally, automatically launch your default web browser and display the *dEX* home page

Applications such as a web browser, FTP client, *DeTransfer* or a Modbus client can then connect to the logger's services using the 127.1.1.1 address, and *DtUsb* will forward their requests on to the logger.

Note *DtUsb* assumes that all logger services are operating using their default port numbers. If you experience problems accessing a particular service, check the following *DT80* profile settings

```
PROFILE COMMAND_SERVER PORT=7700
PROFILE HTTP_SERVER PORT=80
PROFILE MODBUS_SERVER TCPIP_PORT=502
```

Remember also that the USB port function must be set to **COMMAND** (which is the default) in order for *DtUsb* to work, i.e.

```
PROFILE USB_PORT FUNCTION=COMMAND
```

DtUsb GUI

For the most part, *DtUsb* is intended to be invisible – its main purpose is simply to provide a TCP/IP connection over USB so that *dEX* and other logger services can be accessed.

However, *DtUsb* does include a simple graphical user interface (GUI). To access this, double click on the purple icon while a logger is connected. Alternatively, you can find a link to *DtUsb* on the Windows Start menu, in the **dataTaker** folder.

The *DtUsb* GUI comprises three screen, selected by clicking on the tabs along the top. Each screen contains the same three buttons along the bottom:

- **Quit** will terminate *DtUsb*, which will mean that the logger's TCP/IP services will no longer be available. This should normally only be used if you wish to use the direct "COM port" interface to the logger, rather than the TCP/IP interface.
- **Hide** will close the GUI, but *DtUsb* will keep running. Closing the window with the red X button will do the same thing.
- **Apply** will apply any changes you have made on the **Configuration** tab.

Loggers Screen

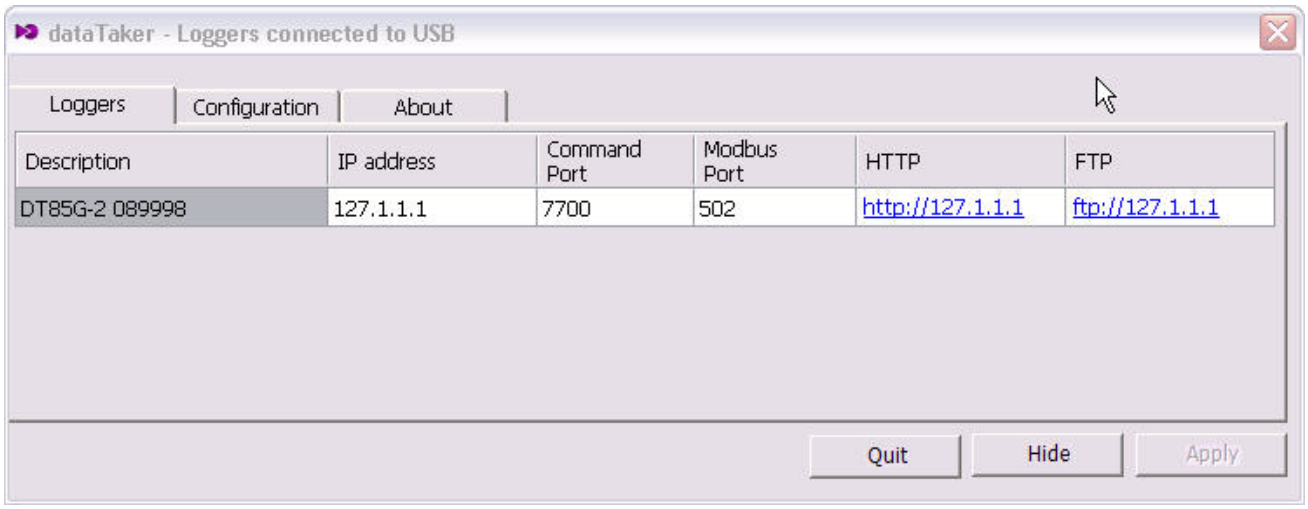


Figure 58: Main DtUsb screen

The **Loggers** tab shows a list of all connected loggers, along with their IP addresses and the port numbers to use to access their services.

For the HTTP (web) and FTP services, links are provided which will open a web browser window. The HTTP link will display the *dEX* home page, while the FTP link will display the web browser's inbuilt FTP client, allowing you to browse the logger's file system.

To access the command server (e.g. in *DeTransfer*) you would create a connection using the indicated IP address and port number (127.1.1.1 port 7700 in this case). To access the *DT80* Modbus server you would enter a similar thing into your Modbus client application.

Note that the port numbers may not necessarily be the "normal" ones shown in the example. For example, if there is a web or FTP server running on your PC then *DtUsb* will automatically assign different port numbers in order to avoid conflicts – for example, port 81 instead of port 80 for the web interface.

Configuration Screen

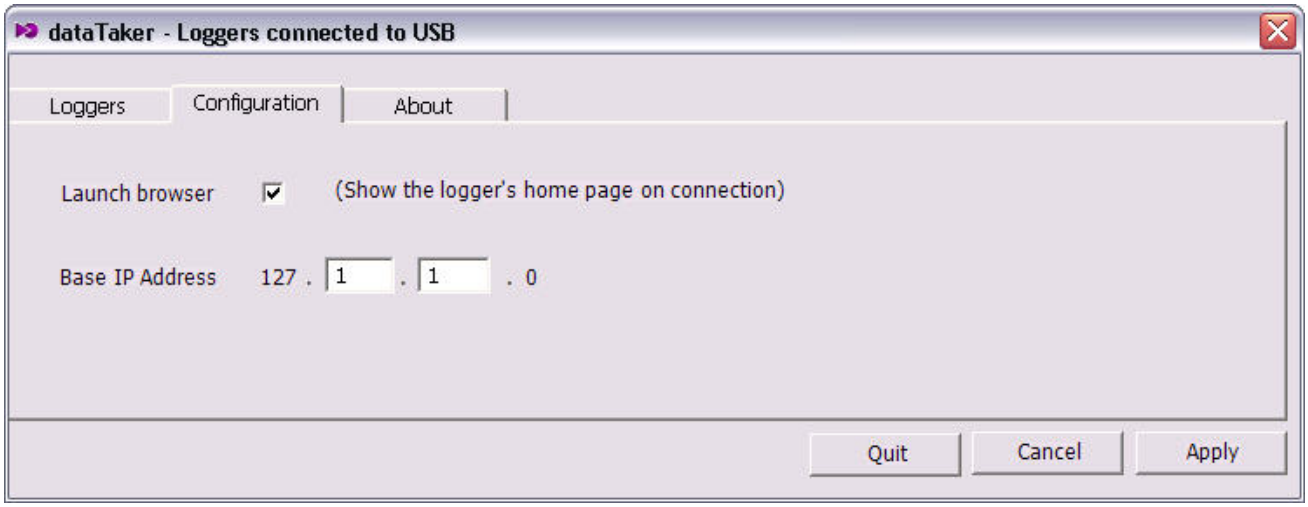


Figure 59: DtUsb Configuration Screen

This screen allows you to select

- whether the *dEX* home page is automatically launched each time a logger is plugged in
- the base IP address that *DtUsb* presents to other applications. This would only need to change if there was some sort of conflict with other software on your computer.

Sleep Mode

If the *DT80* enters low power sleep mode then its USB interface will be reset. To the host computer, it will look like the USB cable has been unplugged, so the configured COM port will disappear.

When the *DT80* wakes, the PC will detect that a USB device has been connected, and re-create the COM port. The application that was using the COM port will, however, most likely not automatically re-connect. For example, *DeTransfer* and *DeLogger* will require you to manually re-establish a connection.

For this reason it is recommended that the logger not be allowed to go to sleep while the USB cable is connected. By default, low power sleep mode is automatically disabled if a USB cable is connected.

RS-232 Communications

Direct RS-232 Connection

For applications where the *DT80* is to be directly connected to a nearby computer, **USB** is normally the preferred communications medium. However, you may wish to use a direct **RS232** connection if:

- your computer has no available USB ports
- you need the *DT80* to go into low power sleep mode between scans, and you want to continue to receive real-time data returns; or you want to be able to wake the *DT80* by sending a character (See *Sleep Mode* *(P231)*)
- the required cable length is longer than about 5 metres.

Normally the *DT80's* **host RS232 port** *(P170)* is used when making a direct RS232 connection to a host computer. However the **serial sensor port** *(P171)* can also be used.

To set up a direct RS232 connection you will need a "cross-over", or "null-modem" cable. Suitable cables may be ordered for this purpose (*dataTaker* product code IBM-6 for host port connection, or CAB-015 for serial sensor port). See *Cables* *(P319)* for wiring information.

It is also possible to use a simpler 3-wire cable (**RXD**, **TXD** and **GND**) although this will mean that hardware flow control is not possible.

If your computer has no RS232 ports (as is the case for many laptop models) a USB to serial adapter may be used.

Cable Length

Although the RS-232 standard specifies a cable of not more than 4 metres (15 feet), longer cables can be used. It's possible to use RS-232 cable runs of 100 metres or more, but to achieve reasonably error-free communication these generally need to have heavier wires and a slower baud rate may be necessary.

RS-232 Flow Control

Flow control (or **handshaking**) is the means by which communicating devices (such as the *DT80* and a host computer) control each other's transmission of characters to avoid data loss. The receiver uses flow control to disable transmissions by the sender if the receiver's input buffer is at risk of overflowing and thereby losing data.

The *DT80* supports all methods of flow control:

- Software flow control (also known as XON/XOFF flow control)
- Hardware flow control (also known as RTS/CTS flow control)
- No flow control

Software Flow Control

In this mode, the receiver controls the flow of characters by transmitting

- the XOFF character (ASCII 19) to stop the sender from sending further characters
- the XON character (ASCII 17) to allow the sender to resume sending characters.

If the *DT80* receives an XOFF character, it will stop transmission within two character periods. If no XON is received within 60 seconds (see *P26* (P201)) the *DT80* will resume transmitting anyway.

Hardware Flow Control

With hardware flow control, the transmission of characters is managed by the **RTS** (Request To Send) and **CTS** (Clear To Send) signals. For a DTE device such as a computer or the *DT80:*

- the RTS signal is an output; the device activates this signal while it is able to receive data
- the CTS signal is an input; the device will only transmit if this signal is active.

So if a computer and the *DT80* are set up to communicate using hardware flow control, then the RTS and CTS lines must be "crossed over". Thus when one end deactivates its RTS signal then the other will see its CTS signal deactivate, causing it to stop transmitting.

The *DT80* communications cable (product code IBM-6) has the RTS/CTS lines connected in this crossover manner – see *Host Port null modem cable* (P319).

Note that for a DCE device (e.g. a modem), the RTS and CTS functions are swapped (as are the TXD and RXD pins). This allows a "straight through" cable to be used when connecting a *DT80* to a modem.

Hardware flow control is inherently more reliable than software flow control, because the flow control state (send/don't send) is continuously indicated by the hardware signals. Software flow control can get into difficulties if line noise causes an XON or XOFF character to be lost, for example.

Hardware flow control is therefore the preferred method. It is not, however, the default because it can only be used if the cable is wired appropriately and the host computer is configured to use hardware flow control. (In this sense software flow control is a little more "forgiving").

If the RS232 cable is accidentally disconnected, the *DT80* will no longer see **CTS** active, so it will stop transmitting. If, however, this condition persists for more than 60 seconds (see *P26* (P201)), the *DT80* will conclude that the host computer is no longer connected and will stop trying to transmit, until **CTS** again becomes active.

No Flow Control

The *DT80* can also be set to use no flow control, in which case there is no control of the sender by the receiver. Use this setting with care, and only where there is no risk of the receiver being over-run by excess data from the sender, otherwise data loss will occur.

Sleep Mode

If the *DT80* is in low power sleep mode, it can be woken by sending a character to the RS232 port (either host port or serial sensor port). Note, however, that the character that was sent will be discarded, if other characters are sent immediately afterwards they may be discarded, too.

It is recommended that the *DT80* be woken by sending a CR character, then waiting at least 500ms before sending any commands. (Note that the "Wakeup Required" option in DeTransfer can be used to automatically prefix all commands by the abovementioned wakeup sequence.)

Note that only the RS232 ports can be used to wake the *DT80* in this way, because when the *DT80* goes to sleep any Ethernet or USB connections are terminated.

This also means that the RS232 port can be used to monitor real time data returns where the *DT80* is configured to go to sleep between scheduled scans – something which is not possible with the USB or Ethernet port.

Host RS-232 Port

The *DT80* has a 9-pin male connector for RS-232 serial communication to a computer or modem. The port is configured as a DTE (Data Terminal Equipment) device, and the pinout is the same as that used on a PC. See *RS-232* (P319) for more details.

Configuring the Host RS-232 Port

There are three parameters that need to be set for any RS232 port, and the *DT80*'s port is no exception:

- baud rate (data transfer rate in bits per second) *DT80* default is **57600**.
- serial framing format (number of data bits, parity type, number of stop bits) *DT80* default is "**N,8,1**" – no parity, 8 data bits, 1 stop bit.
- flow control (mechanism for one computer to tell the other to stop sending) *DT80* default is **software** flow control (special characters are used to signal "stop" and "go").

It is essential that both ends of an RS232 link be configured identically – same baud rate, framing and flow control.

A fourth parameter that needs to be set for the *DT80* host port is the **port function**, which specifies the protocol used by the port – command, PPP, Modbus or generic serial.

PROFILE Settings

To view the current host port settings use the following command:

```
PROFILE HOST_PORT
[HOST_PORT]
  BPS = 57600
  DATA_BITS = 8
  STOP_BITS = 1
  PARITY = NONE
 *FLOW = HARDWARE
  FUNCTION = COMMAND
```

which lists the current baud rate, framing format, flow control and port function. An asterisk indicates a non-default setting. See *Profile Settings* (P204)) for more details.

If required, these settings can be changed using individual **PROFILE** commands, i.e.:

```
PROFILE HOST_PORT key=value
```

The following keys are defined:

Key	Value	Default
BPS	baud rate. Use **300**, **600**, **1200**, **2400**, **4800**, **9600**, **19200**, **38400**, **57600** or **115200**.	**57600**
DATA_BITS	can be **7** or **8**	**8**
STOP_BITS	can be **1** or **2**	**1**
PARITY	can be **N** (none), **O** (odd) or **E** (even)	**N**
FLOW	**NONE** (no flow control) **SOFTWARE** (XON/XOFF) **HARDWARE** (RTS/CTS)	**SOFTWARE**
FUNCTION	port function (see below)	**COMMAND**

For example, the following commands would configure the host port for serial connection to a Modbus client (e.g. a SCADA system), using the "standard" Modbus settings (19200 baud, 8 data bits, 1 stop bit, even parity, no flow control):

```
PROFILE HOST_PORT BPS=19200
PROFILE HOST_PORT PARITY=EVEN
PROFILE HOST_PORT FLOW=NONE
PROFILE HOST_PORT FUNCTION=MODBUS
```

Note that these settings, as with all profile settings, will temporarily revert to default settings in the event of a "triple push" reset, see *Safe Mode* (P211)).

Note Do not use software flow control (SWFC) if the port is using a binary (non-ASCII) protocol, such as Modbus or PPP or some serial sensor protocols. This is because flow control characters (XON/XOFF) may legitimately appear in binary data, and if they do then they will be stripped out. This will cause data errors.

Port Function

The possible settings for the host port **FUNCTION** parameter are:

- **COMMAND** (default) – the port accepts *DT80* commands sent directly over the serial interface. The port will automatically switch to PPP mode if an incoming PPP connection is detected. When the PPP connection is closed the port will go back to accepting direct commands.

- **PPP** – the port accepts PPP connections only.
- **SERIAL** – the port is controlled by the current job, using the **2SERIAL** channel.
- **MODBUS** – the port receives and processes incoming serial Modbus requests.
- **MODBUS_MASTER** – the port is used for polling a Modbus sensor device, as specified in the current job using the **2MODBUS** channel.
- **DISABLE** – the port is disabled. This setting reduces power consumption.

Temporary Settings

The Host RS232 communications parameters can also be temporarily set by the command

PH=*baud*,*parity*,*databits*,*stopbits*,*flow-control*

where:

Parameter	Settings	Default
baud	is the required baud rate. Use **300**, **600**, **1200**, **2400**, **4800**, **9600**, **19200**, **38400**, **57600** **57600** or **115200**.	**57600**
parity	can be **N** (none), **O** (odd) or **E** (even)	**N**
databits	can be **7** or **8**	**8**
stopbits	can be **1** or **2**	**1**
flow-control	**NOFC** (no flow control) **SWFC** (software flow control, i.e. XON/XOFF) **HWFC** (hardware flow control, i.e. RTS/CTS)	**SWFC**

These parameters may be specified in any order and all are optional. Note that the port function cannot be set using this command.

For example, the command

PH=115200,HWFC

sets the RS232 port to 115200 baud, no parity, 8 data bits, 1 stop bit, and hardware flow control.

These settings will be reset to their defaults by a hard reset (e.g. **HRESET**).

You can also check the *DT80*'s current RS232 parameters using the **PH** command, e.g.:

```
PH
RS232,57600,N,8,1,SWFC
```

Serial Sensor Port

(Not applicable to DT81/82E)

The *DT80* serial sensor port is normally used to control serial sensor devices. It is, however, a general purpose serial port which is largely equivalent in functionality to the host RS232 port.

The *DT80* serial sensor port:

- can be configured for either the RS-232, RS-422 or RS-485 comms standard. RS-232 supports a single point-to-point connection; the other standards support multiple devices in a multi-drop configuration (for certain protocols).
- has a differential transmitter and receiver that provide for the different serial standards
- has RTS/CTS handshake lines (RS232 only)
- supports baud rates of 300 to 57600 baud
- supports the serial command, serial Modbus, PPP and generic serial protocols
- does not provide any modem control functions

Connecting to the Serial Sensor Port

The *DT80* serial sensor port terminals have different functions depending upon the configured serial standard (RS232, RS422 or RS485).

Terminal	RS232	RS422	RS485	Wake
Tx **Z**	Transmit Data	Transmit Data– (A)	Data– (A)	
Rx **A**	Receive Data	Receive Data+ (B)		☑
RTS **Y**	Handshake output	Transmit Data+ (B)	Data+ (B)	
CTS **B**	Handshake input	Receive Data– (A)		☑

D GND	Signal Ground	Ground	Ground

Figure 60: The DT80's Serial Channel terminals (DTE)

Note that:

- The RTS and CTS handshake/control signals are available for RS232 only
- The DGND terminal is the signal return (common) for RS232. RS422/485 use differential signalling – the ground is not used as a reference, but it should still be connected to avoid excessive common mode voltages.
- Activity on either of the indicated terminals (i.e. **Rx/A** and **CTS/B**) will wake the logger from sleep mode, although the data in the particular message that woke the logger will be lost. Note also that if the Wake feature is required and RS485 is being used then it will be necessary to link the Data terminals (**Tx/Z** and **RTS/Y**) to the wake-enabled terminals (**Rx/A** and **CTS/B**).

RS232 Connection

The serial sensor port is wired as a DTE device so the data lines must be "crossed over" when connecting to another DTE device. That is, the *DT80*'s **Tx** output connects to the sensor's **RxD** input, and vice versa.

The handshaking signals, if used, must also be crossed over, i.e. **RTS** connects to **CTS** and vice versa.

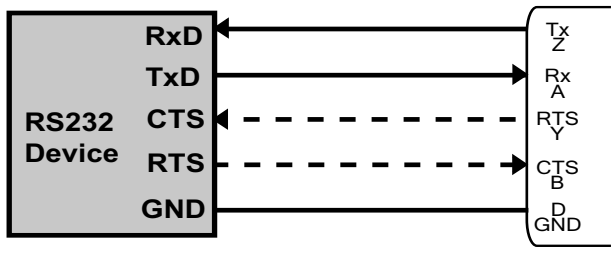


Figure 61: Serial sensor port RS232 connection. RTS/CTS connections are optional.

A cable suitable for connecting the *DT80* serial sensor port to a PC serial port may be ordered (*dataTaker* part number CAB-015). See also *Serial Sensor Port null modem cable* (P320).

RS422 Connection

RS422 allows for **multi-drop** connection, where one or more sensors are connected in parallel. The *DT80* is typically the "master" device in the network and is therefore wired so that its transmissions will be received by all slave devices. The slaves' transmit lines are all tied together, which means that only one slave is permitted to transmit at any one time. It is up to the communications protocol to ensure that this is the case – typically each slave will be assigned a unique address and will only respond if it receives a request from the master that is addressed to it.

RS422 uses **full duplex** differential signalling: two wires for transmit (**Y** and **Z**) and two wires for receive (**A** and **B**). Be sure to observe the correct signal polarity, as shown in the diagram. Some devices label their terminals as **A** or **B**, some as **+** or **–**.

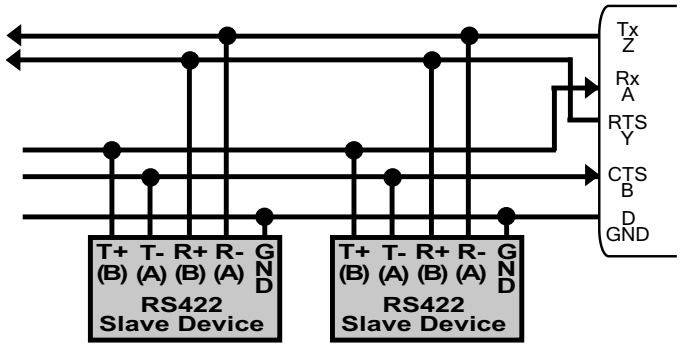


Figure 62: Serial sensor port RS422 connection, assuming that the DT80 *is the designated master device.*

RS485 Connection

RS485 uses **half duplex** differential signalling: there is just one pair of wires, which is used for both transmit and receive. Be sure to observe the correct signal polarity, as shown in the diagram. Some devices label their terminals as **A** or **B**, some as **+** or **–**.

Notice that with RS485, all devices including the *DT80* are wired symmetrically: there is no distinction between "master" and "slave", at least from a wiring perspective.

An RS485 network should normally be cabled as a single linear "backbone", with relatively short "stub" connections to each device. For long cable runs or high baud rates a 100Ω termination resistor at each end of the main cable is recommended.

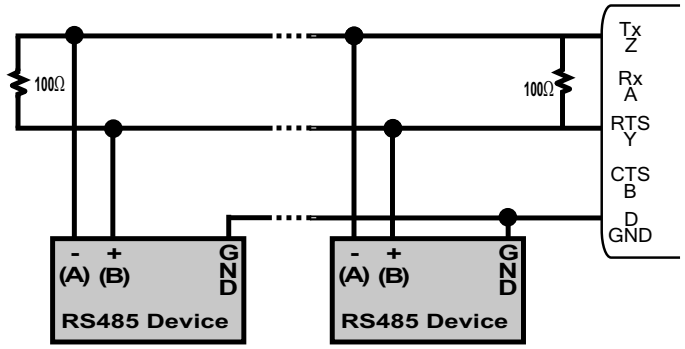


Figure 63: Serial sensor port RS485 connection

Configuring the Serial Sensor Port

The following parameters need to be set for the serial sensor port:

- port mode (RS232, RS422 or RS485) – default is **RS232**.
- baud rate (data transfer rate in bits per second) – default is **1200**.
- serial framing format (number of data bits, parity type, number of stop bits) – default is "**N,8,1**", i.e. no parity, 8 data bits, 1 stop bit.
- flow control (mechanism for one computer to tell the other to stop sending) – default is **no flow control**.
- port function (protocol to be used: command, PPP, Modbus or generic serial) – default is **generic serial**.

PROFILE Settings

To view the current serial sensor port settings use the following command:

```
PROFILE SERSEN_PORT
[SERSEN_PORT]
*BPS = 9600
 DATA_BITS = 8
 STOP_BITS = 1
 PARITY = NONE
 FLOW = NONE
 MODE = RS232
 FUNCTION = SERIAL
```

which lists the current baud rate, framing format, flow control, port mode and port function. An asterisk indicates a non-default setting. See *Profile Settings* (P204) for more details.

If required, these settings can be changed using individual **PROFILE** commands, i.e.:

```
PROFILE SERSEN_PORT key=value
```

The following keys are defined:

Key	Value	Default
BPS	baud rate. Use **300**, **600**, **1200**, **2400**, **4800**, **9600**, **19200**, **38400** or **57600**.	**1200**
DATA_BITS	can be **7** or **8**	**8**
STOP_BITS	can be **1** or **2**	**1**
PARITY	can be **N** (none), **O** (odd) or **E** (even)	**N**
FLOW	**NONE** (no flow control) **SOFTWARE** (XON/XOFF) **HARDWARE** (RTS/CTS)	**NONE**
MODE	signal standard: **RS232**, **RS422** or **RS485**	**RS232**
FUNCTION	port function (see below)	**SERIAL**

If required, these settings can be changed using individual **PROFILE** commands. See *Profile Settings* (P204) for details on the possible values for these settings.

For example, the following commands would configure the serial sensor port for the control of serial sensor devices on an RS485 network, running at 38400 baud

```
PROFILE SERSEN_PORT BPS=38400
PROFILE SERSEN_PORT MODE=RS485
```

Note Do not use software flow control (SWFC) if the port is using a binary (non-ASCII) protocol, such as Modbus or PPP or some serial sensor protocols. This is because flow control characters (XON/XOFF) may legitimately appear in binary data, and if they do then they will be stripped out. This will cause data errors.

Port Function

The possible settings for the serial sensor port **FUNCTION** parameter are:

- **SERIAL** (default) – the port is controlled by the current job, using the **1SERIAL** channel.
- **COMMAND** – the port accepts *DT80* commands sent directly over the serial interface. The port will automatically switch to PPP mode if an incoming PPP connection is detected. When the PPP connection is closed the port will go back to accepting direct commands.
- **PPP** – the port accepts PPP connections only.
- **MODBUS** – the port receives and processes incoming serial Modbus requests.
- **MODBUS_MASTER** – the port is used for polling Modbus sensor devices, as specified in the current job using the **1MODBUS** channel.
- **DISABLE** – the port is disabled. This setting reduces power consumption.

Temporary Settings

The serial sensor port communications parameters can also be temporarily set by the command

PS=*mode*,*baud*,*parity*,*databits*,*stopbits*,*flow-control*

where:

Parameter	Settings	Default
mode	specifies the signal standard: **RS232**, **RS422** or **RS485**	**RS232**
baud	is the baud rate. Use **50**, **75**, **110**, **150**, **300**, **600**, **1200**, **2400**, **4800**, **9600**, **19200**, **38400** or **57600**.	**1200**
parity	can be **N** (none), **O** (odd) or **E** (even)	**N**
databits	can be **7** or **8**	**8**
stopbits	can be **1** or **2**	**1**
flow-control	**NOFC** (no flow control) **SWFC** (software flow control – RS232/RS422 only) **HWFC** (hardware flow control – RS232 only)	**NOFC**

These parameters may be specified in any order and all are optional. Note that the port function cannot be set using this command.

For example, the command

PS=RS485,9600

sets the port to RS485 mode, 9600 baud.

These settings will be reset to their defaults by a hard reset (e.g. **HRESET**).

You can also check the *DT80*'s current serial sensor port parameters using the **PS** command, e.g.:

```
PS
RS232,1200,N,8,1,NOFC
```

Modem Communications

Modem (Remote) RS-232 Connection

Another common way of communicating with the *DT80* is to connect its Host RS-232 port to a wired or wireless modem, which communicates with another modem connected to the host computer at the other end of the comms link. This way, the *DT80* can be across town or across the world from the host computer, and the link can use PSTN (landline), radio, GSM (cellular) or satellite communication. This is known as a **modem connection** to a **remote** *DT80*.

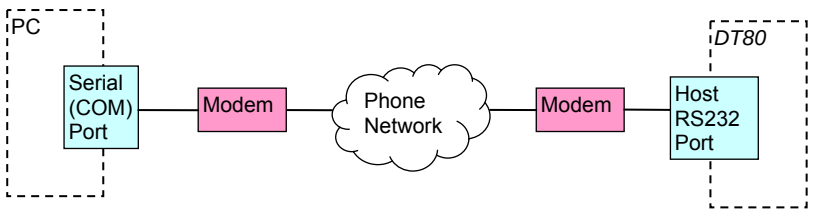


Figure 64: Modem connection

The "phone network" cloud in the diagram could be:

- a dedicated wired or wireless link, e.g. a leased line or a dedicated radio link

- the public switched telephone network (PSTN)
- a cellular or satellite mobile network.

The *DT80* supervises the modem using standard Hayes-compatible "AT" commands. Certain command strings are configurable, to allow the widest possible range of modems to be supported.

The *DT80* can also control the modem's power supply. If this facility is used, the *DT80* can automatically reset the modem if it determines that this is necessary. See *Powering the DT80's Modem* (P177).

Automatic Modem Detection

A *DT80* uses the state of its Host RS-232 port's **DSR** terminal to determine whether a modem is connected to the port. (**DSR** = "Data Set [i.e. modem] Ready")

If the DSR terminal is not held active by the connected device, the *DT80* assumes that it's connected directly to the host computer and operates accordingly.

If the *DT80*'s **DSR** terminal is held active by the connected device, the *DT80* assumes that it's connected to a modem and operates accordingly, initialising the modem, monitoring other Host RS-232 lines to determine when a modem connection to the host computer has been established, and so on.

DT80-to-Modem Cable

As discussed above, for the *DT80* to recognise that it's connected to a modem and operate accordingly, the *DT80* must see the signal at the **DSR** terminal (pin 6 of the *DT80*'s host RS232 port) as active. There are two ways to ensure this:

- Connect the *DT80*'s Host RS-232 port to a modem using a straight-through comms cable, as shown in *Host Port modem cable* (P319). This will connect the *DT80*'s **DSR** input to the modem's **DSR** output. Nearly all modems will drive the **DSR** signal active while they are switched on.
- If a modem is being used that does not drive its DSR line active when turned on, you can hardwire **DSR** to **DTR** at the *DT80* end of the modem cable. This simulates an active **DSR** terminal, convincing the *DT80* that it's connected to a modem.

The cable will also require the following signals to be connected through to the modem:

- **RTS** and **CTS** signals, to allow hardware flow control (see *RS-232 Flow Control* (P171))
- **DCD** signal, to allow the *DT80* to detect when the modem is on-line (see *Modem Communications Operation* (P177)).

Modem Initialisation

Configuring Your Modem

Modems are highly configurable devices with many different parameters that can be adjusted. To make this long list of parameters easier to manage, modems normally support a number of different configuration **profiles**. Each profile consists of a complete set of parameter values. As a minimum, there would be a fixed **factory settings** profile, and a user-configurable **default** profile. The default profile's settings are automatically loaded when the modem is reset or powered up.

Although the *DT80* includes support for automatically sending initialisation commands to the modem, it is recommended that you fully pre-configure the modem, and write the configuration to the modem's default profile, before connecting it to the *DT80*. This ensures that whenever the modem resets due to power loss or other reason it will start with the correct configuration.

Sending Modem Commands

Refer to your modem's user's manual for information on how to go about pre-configuring the modem. This is usually done by connecting the modem to a PC serial port and running a terminal program such as *Hyperterminal* or *DeTransfer* so that you can then send "AT" commands to configure the modem.

You can also use the **SSDIRECT** command (see *Serial Sensor Direct Mode* (P286)) to configure a modem that is already connected to the host port of the *DT80*. To use this feature, connect to the *DT80* using the USB or Ethernet port, then send the command

```
SSDIRECT 2
```

to enable Serial Sensor Direct Mode. You can now interact with a modem attached to the host RS232 port. for example, you can sent AT commands and see its responses (assuming the modem is in command mode). When you're done, enter

```
ENDSSDIRECT
```

.

Recommended Option Settings

The following is a list of items that should be set in the modem's default profile. You should check your modem user's manual to determine the exact command to use for each setting.

It is recommended that you start by resetting the modem to its factory defaults so that you have a known starting point. This is particularly important if someone else has used the modem before and you are uncertain of the settings used. For most modems the **AT&F** command will load the factory default profile. After this command has been issued, you can then set all other settings as detailed below and as required for your specific application.

- **DSR always on**: The **DSR** (data set ready) signal from the modem must be active while the modem is turned on, as this is how the logger determines that a modem is connected. Most modems do this by default, if not then you must set the modem do this (typically by using the command **AT&S0**). If the modem cannot be configured to operate in this way then the logger must be tricked by connecting **DSR** to **DTR** at the logger side, but this should be done as a last resort as it is not as robust a method. It is important for the logger to know that a modem is connected so that it can avoid sending normal data output to the modem when the modem is in command mode.
- **DCD follows carrier state**: The **DCD** (data carrier detect) signal must be set to follow the carrier state, as this is how the logger determines when a connection has been established with another modem. Most modems do this by default, if not then you must set the modem to do this (typically using the command **AT&C1**).
- **Hardware flow control**: We recommend that you always use hardware flow control on the modem and the logger. For most modems this is the default. It is typically set using the **AT&K3** command.
- **Force reliable (error correcting protocol) mode**: You should ensure that the modem connection always uses an error correcting protocol such as LAPM or MNP. This is required to ensure the flow control information is passed between the logger and PC based application as well as to eliminate line errors that may corrupt the data transmission. If an error correcting protocol is not used then line errors and flow control problems can cause data loss. Many modems will fall back to a non error correcting mode if an error correcting protocol cannot be agreed with the other modem. This should be avoided as it can cause data loss. Many PSTN modems can be set to force reliable mode using the **AT\N2** command. That is, they will not connect at all if an error correcting protocol is unavailable.
- **Auto answer**: The *DT80* does not issue any commands to the modem to answer a call. Therefore, if dial-in functionality is required, the modem must be set to auto-answer incoming calls. For most modems the command **ATS0=4** will set the modem to auto-answer incoming calls after 4 rings. This setting may be omitted if you do not need dial-in functionality, in which case the modem will ignore incoming calls.
- **Don't echo commands**: Most modems will echo incomming commands. This is not desirable when used with a *DT80* as the echo may be treated as a command by the logger which will only confuse it. For most modems the command **ATE0** will turn off echo of modem commands.
- **Quiet mode**: Most modems will issue messages whenever a command is sent to the modem or a connection is made or dropped. This is not desirable when used with a *DT80* as the message may be treated as a command by the logger which will only confuse it. For most modems the command **ATQ1** will disable the output of such messages.
- **DTR hangup**: Whenever the logger wants to hang up a connection it will set the **DTR** (data terminal ready) signal to inactive. The modem should be set such that it will drop the connection whenever it sees **DTR** inactive. This behaviour can be set for most modems with the command **AT&D2**.
- **Fixed local baud rate**. Most modems will set their local baud rate automatically ("autobaud") to match that of the connected device, once it sees an AT command from the device. Some modems, such as some GSM/CDMA modems, will only autobaud up to a particular maximum rate (such as 19200). To use rates above this you must set the baud rate to a fixed value using a command to the modem. The way to control this varies considerably across modems. For example on some modems the command **AT#BDR** can be used to fix the local baud rate.

  To ensure reliable communications with the modem under all conditions it is in fact recommended that you always fix the modem's baud rate. This should be set to match the baud rate of the *DT80*'s host serial port (by default 57600). If the modem's baud rate cannot be set then you need to ensure that the logger's modem initialisation string *(P177)* contains at least one AT command so that the modem can autobaud when it is sent.
- **Application specific settings**. You may need to set other settings in the modem that are particular to your application.

After entering the required configuration settings, it is necessary to tell the modem to store them into its default profile. This is normally done using the **AT&W** command.

To verify that the settngs have been set correctly, power cycle the modem and then send the **AT&V** command to output the current settings and check that the initialisation commands above have been set for the active profile.

Example

The following initialisation commands are suitable for PSTN modems that use a Rockwell chipset. They may be suitable for other types as well. Please check the modem's users manual to confirm that it supports all the AT commands specified here before using these commands.

```
AT&F
ATE0Q1&D2S0=4&C1&S0\N2%C2&K3#BDR=24
AT&W
```

Note If *DeTransfer* is used to send these commands to the modem then the **** character must be entered as ****. Also note that because these incantations include a command to fix the baud rate to 57600, the terminal program must be set to 57600 baud, otherwise the subsequent command (**AT&W**) would not be recognised.

The above AT commands decode as follows:

Command	Description
&F	set all parameters to factory defaults
E0	no echo
Q1	quiet mode (no messages)
&D2	hang up if DTR inactive

S0=4	auto-answer after 4 rings
&C1	DCD follows carrier
&S0	DSR always on
\N2	don't connect unless error correction is active
%C2	enable V42bis data compression
&K3	enable hardware flow control (RTS/CTS)
#BDR=24	set baud rate to 57600 (24 x 2400) – disable autobaud
&W	write settings to default profile

Modem Initialisation String

The *DT80* automatically attempts to initialise the device attached to its Host RS-232 port when it first detects the **DSR** signal as active and in certain other circumstances. This is done by sending the initialisation string specified by the **INIT** profile key (**HOST_MODEM** section, see *Profile* (P204))

The modem should already have been pre-configured (see *Configuring Your Modem* (P175)), so the recommended initialisation string is simply **AT**, which is the default.

Sending **AT** will ensure that the modem can autobaud, if it has been configured to do so.

Powering the *DT80*'s Modem

If required, the *DT80* can control power to the modem, so that it can be powered down under program control when not in use.

This can be done using either:

- the **RELAY** output – see *DO5 – Latching Relay Output* (P266); use **1RELAY=1** to switch on modem power, **1RELAY=0** to turn off, or
- one of the digital outputs **1D-4D** driving an external relay – see *DO1 – Driving a Relay* (P265); use **1DSO=0** to switch modem power on, **1DSO=1** to turn off, or
- the **12V** power output (DT80/81 Series 2 and DT85 only), provided that the modem draws no more than 150mA.

Automatic Modem Power-Down Reset

The *DT80* provides an additional feature where the modem can be automatically reset (by removing and re-applying power) if it appears to be unresponsive – that is, it has been off-line (i.e. not connected to the remote modem) for a long period of time (12 hours, by default – set this using the **MAX_CD_IDLE** profile key).

To enable this feature, send one of the following **PROFILE** commands:

- If the modem is powered from one of the *DT80*'s digital output channels *n* (where *n* = **1** to **4**), send the command
  PROFILE HOST_MODEM EXT_POWER_SWITCH=*n*DSO
- If the modem is powered via the *DT80*'s relay channel, send the command
  PROFILE HOST_MODEM EXT_POWER_SWITCH=1RELAY
- If the modem is powered via the DT85's 12V power output, send the command
  PROFILE HOST_MODEM EXT_POWER_SWITCH=PWR12V
- If the modem is not powered by either of the above, send the command
  PROFILE HOST_MODEM EXT_POWER_SWITCH=NONE
  to disable the feature.

From then on, the *DT80* will automatically cycle the modem power if it detects it to be unresponsive. It will then send the configured modem initialisation string.

Modem Communications Operation

Dialling In

As the modem is initialised to automatically answer incoming calls, the *DT80* does not have to monitor the **RI** signal at its Host RS-232 port or request the modem to answer the call. But the *DT80* does have to monitor the **DCD** signal to determine when a call has been established.

The *DT80* does not communicate via the RS232 host port unless it determines that a call has been established between itself and a host. When a modem is attached (**DSR** active), the *DT80* monitors the **DCD** signal to determine when it can transmit data and status information, and receive commands:

- When **DCD** is active the *DT80* accepts commands, and returns data and status information – exactly as it would for a direct connection.
- When **DCD** is inactive the *DT80* ignores any received characters and does not transmit data or status information.

This behaviour ensures that any rubbish characters received outside of a call are ignored, and that the *DT80* does not send

characters to the modem that the modem may interpret as commands to switch into a different operating state.

Dialling Out

The *DT80* can also initiate an outgoing modem call, which would typically be done in response to an alarm.

SETDIALOUTNUMBER Command

Send the command
`SETDIALOUTNUMBER"`*digits*`"`
to the *DT80* to specify the telephone number to be dialled by the **DIAL** command to establish a connection to the host computer.

DIAL Command

The **DIAL** command causes the *DT80* to instruct its modem to dial out to the telephone number specified by **SETDIALOUTNUMBER**. If a call cannot be placed for any reason, the command is ignored. This is often used as an alarm action command to cause the *DT80* to dial out when an alarm condition arises (see *Alarm Action Processes* (P81)).

HANGUP Command

The **HANGUP** command causes the *DT80* to instruct its modem to hang up (disconnect) the current dial-out or dial-in connection. If there is currently no connection, **HANGUP** is ignored. This can be used in an alarm action command to cause the *DT80* to hang up a call in progress when an alarm condition arises.

Example — Modem Control Commands

The use of the *DT80*'s modem control commands is demonstrated in the following program:

```
BEGIN"FLUFFY"
SETDIALOUTNUMBER"12345678"
RA10M
 'Read boiler temp
 1TK(=1CV,W)
 IF(1CV>120){DIAL}
END
```

Every 10 minutes, the program checks the boiler temperature and then, if it exceeds 120°C, instructs the modem to initiate a dial-out to phone number **12345678**.

Modem Status

The system variable 25SV (P36) gives an indication of the current state of the modem. It can be used with alarms to determine the current state of the modem connection and to behave accordingly.

Modem Diagnostics

If you experience problems with setting up a modem, it can be helpful to switch on diagnostic messages by setting **P56=16**. These messages are output to the active communications port and indicate events (e.g. DCD signal going active) and *DT80* actions (e.g. initialisation commands sent to the modem) as they occur.

Set **P56=0** to disable the diagnostic messages.

Setting Up a Remote Connection

The following is a brief summary of the steps involved in setting up a remote modem connection between the *DT80* and a host computer.

1. Pre-configure the modem as described in *Configuring Your Modem* (P175) and save the settings to the modem's default profile.
2. Connect a local PC to the *DT80* using a USB or direct RS232 connection and run *DeTransfer*/*DeLogger*.
3. Set the required profile settings to configure the host port and modem. For example:
   ```
   PROFILE HOST_PORT FLOW_CONTROL=HARDWARE
   PROFILE HOST_MODEM EXT_POWER_SWITCH=3DSO
   ```
   will set hardware flow control (recommended), and configure modem power control using digital output **3D**.
4. Connect power to the modem (in the above example the power would be supplied via a relay driven by **3D**).
5. Connect a suitable comms cable between the serial port on the *DT80*'s modem and the *DT80*'s Host RS-232 port. This cable is normally supplied with the modem, see also *DT80-to-Modem* Cable (P175).
6. At the remote end of the link, connect a suitable comms cable between the serial port on the host computer and the local modem.
7. On the host computer, configure the modem using the Windows control panel. It is recommended that hardware flow control and an error-correcting protocol (e.g. V42) are used.
8. On the host computer, launch suitable terminal software, e.g. *DeLogger* or *DeTransfer*. Set up a connection to use the modem.

9. Attempt to connect to the *DT80* from the host computer.

Visits to Site

If the site is visited where the *DT80* and the modem are installed, the *DT80* can be communicated with directly from a PC/Notebook by unplugging the cable from the modem to the *DT80* at the *DT80* end and then plugging in a direct RS232 cable from your PC/Notebook to the *DT80*. Differences in the cable wiring allow the *DT80* to determine the type of connection and to respond appropriately.

Alternatively, a USB cable can be used, in which case the modem cable need not be disturbed.

Ethernet Communications

The *DT80*'s Ethernet port allows you to connect the *DT80* to a TCP/IP based local or wide area network. The *DT80* can then provide the following **services** to client computers:

- access to the *DT80*'s standard **command interface**
- access to the *DT80*'s built-in **web interface** *(P114)*
- access to the *DT80*'s **Modbus server**.
- transfer of files (e.g. job files, store files) to or from the *DT80*'s file system, using the **FTP** protocol *(P188)*

These client computers may be on the desk next to the *DT80* or, via the Internet, on the other side of the world.

TCP/IP Concepts

In order to operate correctly on a TCP/IP network, the *DT80* must know the following:

- its own unique **IP address**
- the **subnet mask** applicable to the network to which it is connected
- (optional) the **gateway IP address** applicable to the network to which it is connected
- (optional) the **DNS server** address applicable to the network to which it is connected.

IP Address

Every device that is connected to a TCP/IP network must have its own unique identifier, called its **IP address**, and the *DT80* is no exception. No two devices in the same network can have the same IP address.

An IP address is single 32-bit integer, but it is normally written as four numbers (each in the range 0-255), separated by periods, e.g. **192.168.2.101**.

Assigning an IP Address

There are two methods of assigning an IP address to the *DT80*'s Ethernet port:

- it can be manually specified in the *DT80*'s profile. This is termed a **static IP address**.
- the *DT80* can automatically obtain a **dynamic IP address** from a **DHCP server** on the local network. Most networks include a Dynamic Host Configuration Protocol (DHCP) server, which is responsible for providing IP addresses to computers connected to the network. If a DHCP server is not available then the *DT80* can assign itself an **Auto-IP** address.

Note that a DHCP server will typically also automatically set the *DT80*'s subnet mask, gateway and DNS server parameters.

Public and Private Addresses

Traditionally, all IP addresses were "public", which meant that if you knew a particular computer's IP address then you could connect to it from any computer on any IP network anywhere in the world. This did, however, present some problems. Firstly, it meant that every computer needed a globally unique IP address, and with the explosive growth of the Internet, IP addresses are simply running out. Secondly, computers with externally visible IP addresses are potentially vulnerable to malicious programs on the Internet which attempt to exploit application or operating system "loopholes" in order to gain control of a computer for nefarious purposes.

Nowadays, the usual practice is to set up private networks, where all computers on the network have a private IP address. In order for these computers to access web servers and such like on the Internet, all external traffic is passed via a **NAT router**, so called because it performs **Network Address Translation**, i.e. it converts private IP addresses into "real" IP addresses and vice versa. The end result is that the computers on the private network can "see out", but external systems cannot "see in" – the router effectively acts as a "firewall" between the secure private network and the Internet.

This is fine for "client" computers such as the one you use for accessing the web or email. For "server" devices (e.g. the *DT80*, which has internal web and FTP servers), NAT can present a problem if you want to be able to access the *DT80*'s servers via the Internet. This will be discussed further in *Accessing the DT80 via the Internet* *(P186)*.

Private IP addresses normally begin with 10.x.x.x, or 172.16.x.x through 172.31.x.x, or 192.168.x.x, or 169.254.x.x. These addresses only need to be unique within the local network. Addresses outside these ranges can normally be assumed to be **public IP addresses**. Public IP addresses need to be assigned by an Internet Service Provider (ISP).

Subnet Mask

The *DT80*'s IP address actually consists of two parts:

- The **network number**, which identifies the network to which the *DT80* and its neighbours are connected.
- The **node number**, which uniquely identifies this *DT80*. No two devices on the network may have the same node number. Also known as a **host number**.

The **subnet mask** is a property of the network to which the *DT80* is connected and specifies which part of the IP address is the network number and which is the node number.

For example, the subnet mask **255.255.255.0** specifies that the first three parts of the IP address are the network number, and the last is the node number within the network. So in this case the IP address **192.168.2.101** would represent node **101** on the "**192.168.2**" network.

Gateway

The *DT80* can communicate directly with any of the nodes connected to its local network. In many cases this is all the connectivity that is required.

If, however, the *DT80* needs to be accessed from farther afield then it needs to know how to communicate with computers on different networks. This is done by assigning one of the computers on the *DT80*'s local network to be a **gateway**. The IP address of the gateway is then entered into the *DT80*.

Now, any time the *DT80* wants to talk to a computer on a "foreign" network it will simply passes the data to the designated gateway and let it sort it out. The gateway may then pass the data on to other gateways, until eventually the data finds its way to its destination. See also *Connection to a LAN* (P180).

As hinted above, if you only want to connect your *DT80* to one computer, or to a few computers which are all on the same local network, then it is not necessary to specify a gateway.

DNS Server

Most networks include a **Domain Name System (DNS)** server. This is responsible for translating names such as **ftp.datataker.com** into numeric IP addresses. If the *DT80* is configured with a valid DNS server address then the current job will be able to access FTP servers by name rather than having to use a raw IP address.

Connecting to the *DT80* Ethernet Port

Important Do not connect your *DT80* to the network until you've configured the *DT80* with a suitable IP address and subnet mask, or selected the "automatic IP address" option. Connecting a device with an invalid or conflicting IP address may cause significant disruption to the operation of the network.

The *DT80*'s Ethernet port is designed to connect to any **10-BaseT Ethernet** compatible network. The port operates at a maximum data rate of 10Mbps.

There are two ways to connect to a network:

- directly connect the *DT80* to a single host computer using a "cross-over" cable. In this case you are effectively creating a new mini-network, with just two devices connected – the *DT80* and the host computer.
- connect the *DT80* to a spare port on an Ethernet hub, bridge or router, using a standard ("straight through) cable. In this case the *DT80* will be joining an existing network.

Note that many recent PC and switch/router models incorporate "auto switching" Ethernet ports. Such devices may be connected to the *DT80* using either a standard or cross-over Ethernet cable.

Direct Connection to a PC

A direct Ethernet connection provides a link between a single PC and the *DT80*.

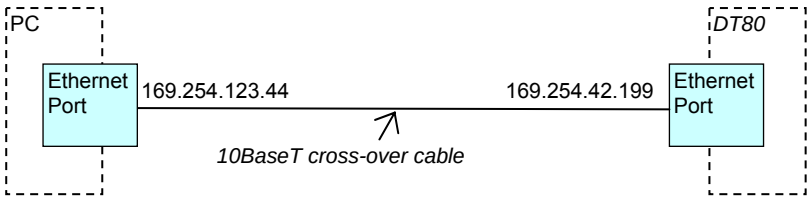


Figure 65: Direct Ethernet connection

In the above example, the PC and the *DT80* have both assigned themselves Auto-IP addresses, as there is no DHCP server available. Auto-IP addresses always begin with 169.254; the latter part of the IP address is semi-random.

Connection to a LAN

By connecting the *DT80* to a local area network (LAN), the *DT80* will be accessible by any of the computers on the LAN, and possibly also by computers on a wide area network or the Internet, depending on how the LAN is set up.

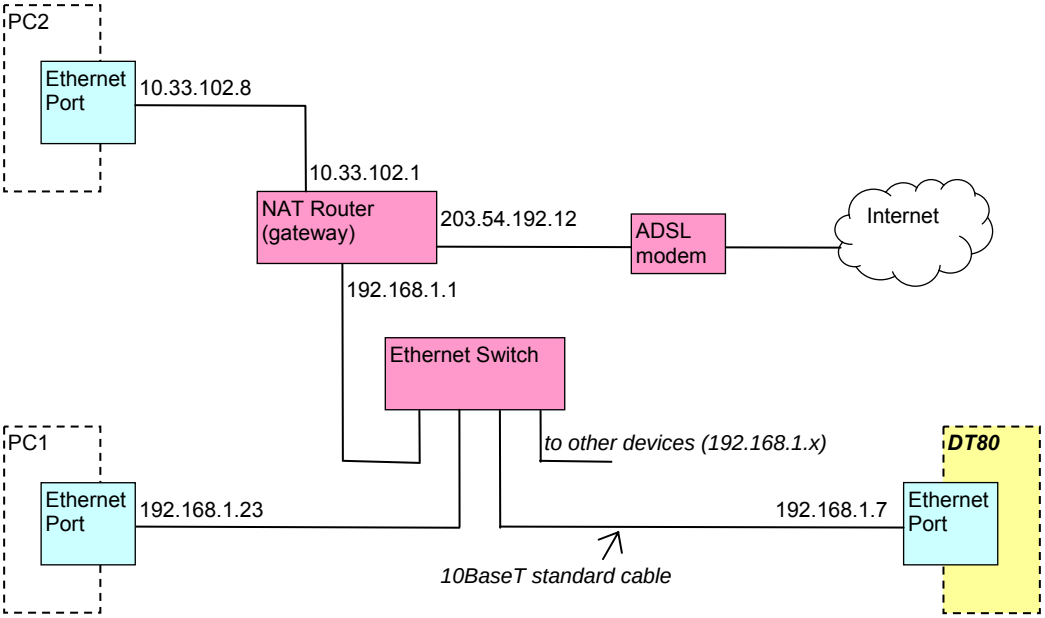


Figure 66: Typical Ethernet LAN

In the above example, the *DT80*, PC1, a router, and possibly some other devices are all connected on the same private LAN "segment", or "subnet". All devices on this particular subnet have IP addresses beginning with 192.168.1. All devices on the same subnet can communicate with each other directly.

PC2, on the other hand, is connected to a different subnet. It cannot directly communicate with the *DT80*; it needs to go via the router. In other words the router acts as a "gateway" between the various subnets, and also, in this case, the Internet.

This all happens automatically, provided that all devices are correctly configured. In particular, the **gateway address** for each device needs to point to the router. So PC1 and the *DT80* would both have their gateway address set to 192.168.1.1, while PC2's gateway would be set to 10.33.102.1.

Note that if a DHCP server is present on the LAN (which will usually be the case), and the *DT80* is configured to use it, then the DHCP server would normally take care of setting all required addresses automatically.

Connection to a Modem-Gateway

Another common connection scenario is where a remote *DT80* is connected to the Internet using a "modem-gateway" device that integrates the modem, NAT router and switch functions into one box. The modem may be a cable, ADSL or wireless (GPRS/3G) modem.

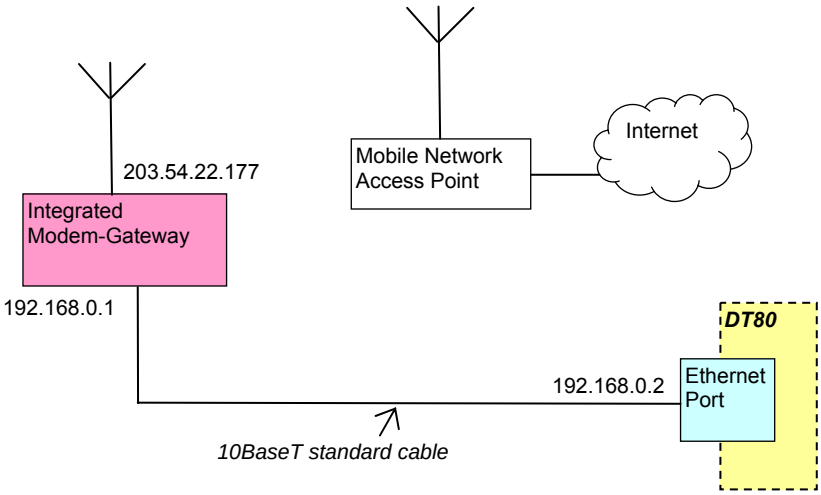


Figure 67: Typical Internet connection using an integrated modem-gateway (wireless modem in this case)

The modem-gateway will typically include a DHCP server, which will automatically set up the required network parameters on the *DT80*, including its IP address.

Ethernet Port Indicators

The two LEDs on the *DT80*'s Ethernet port *(P216)* indicate the following:

- Green LED – **Link OK**; should come on and stay on as soon as you connect the Ethernet cable
- Amber LED – **Activity**; blinks every time a data packet is received

If the green LED does not come on then either the *DT80* Ethernet port is not enabled, or the cable is faulty, or the socket you are connecting to is not connected to an active Ethernet network, or the hub/bridge/router is not powered up.

Note that the amber LED indicates communications activity anywhere on the local network – this activity is not necessarily directed at the *DT80*.

Note These LEDs will only operate if the *DT80* Ethernet port is enabled. The Ethernet port will only be enabled if its IP address has been set, or DHCP has been enabled. (See *How to set up Ethernet* (P183)).

MAC Address

All Ethernet devices have a globally unique 12-digit identifier programmed into them during manufacture. This is called the **MAC Address**. The *DT80*'s assigned MAC address can be viewed using the **EAA** (Ethernet Adapter Address) command, but it cannot be changed. You should not need to be concerned with this address.

Ethernet Commands

Querying Ethernet Parameters

The current Ethernet parameters can be viewed using the following commands

Command	Description	
IP	Returns the *DT80*'s current IP address	
IPSN	Returns the *DT80*'s current IP subnet mask	
IPGW	Returns the *DT80*'s current IP gateway	
EAA	Returns the *DT80*'s Ethernet network adapter address	Set at factory (read-only)

For example:

```
IP
192.168.42.15
IPSN
255.255.255.0
IPGW
192.168.42.3
EAA
00-90-2D-00-12-6B
```

In this example the *DT80* has IP address **192.168.42.15**, and is connected to network **192.168.42.0/24**. The computer or router at IP address **192.168.42.3** is the designated gateway for this network. Any data that needs to be sent to a different network will be sent via this computer.

Setting Ethernet Parameters

All Ethernet parameters are set using profile settings (see *Profile* (P204)), i.e.

```
PROFILE ETHERNET key=value
```

The following keys are defined:

Key	Value	Default
ENABLE	Set to **YES** to enable the Ethernet port, **NO** to disable (saves power)	**YES**
IP_ADDRESS	IP address of *DT80* Ethernet port. May be set to a static IP address, or **AUTO** (obtain an address from a DHCP server)	**AUTO**
SUBNET_MASK	Subnet mask for the network segment to which the *DT80* is connected. This setting will be ignored if a valid subnet mask was obtained from the DHCP server.	**255.255.255.0**
GATEWAY	IP address of the gateway computer/router for network segment to which the *DT80* is connected. This setting will be ignored if a valid gateway address was obtained from the DHCP server.	**0.0.0.0**

For example, the following commands would be used to set the parameters in the above example:

```
PROFILE ETHERNET IP_ADDRESS=192.168.42.15
PROFILE ETHERNET SUBNET_MASK=255.255.255.224
PROFILE ETHERNET GATEWAY=192.168.42.3
```

Alternatively, if a DHCP server was available on the network then you could simply use:

```
PROFILE ETHERNET IP_ADDRESS=AUTO
```

By default, the above command is assigned to one of the *DT80*'s user defined functions, accessible from the front panel; see *User Defined Functions* (P111). This makes it easy to enable Ethernet on a new logger without having to connect to it.

Setting DNS Server address

To set the DNS server address use

```
PROFILE NETWORK DNS_SERVER_1=192.168.42.4
PROFILE NETWORK DNS_SERVER_2=192.168.42.5
```

The first setting is for the primary DNS server; the second is for an optional alternative server, which will only be used if the primary server is offline.

These settings will be ignored if valid DNS server address(es) were obtained from the DHCP server.

How to set up Ethernet

Initial decisions

In order to set up an Ethernet connection to the *DT80*, you need to decide:

- whether the *DT80* will connect directly to a PC (*Figure 65*), or connect to an existing LAN (*Figure 66*)
- whether the *DT80* will use a static (manually configured) or a dynamic (automatic) IP address.

A direct Ethernet connection to a PC will typically be a temporary arrangement, so you would normally choose the automatic (Auto-IP) IP address option.

For a LAN connection, the automatic (DHCP) option is considerably simpler to set up, as the IP address, subnet mask, gateway and DNS server addresses will normally all be set automatically.

The main drawbacks of a dynamic IP address are that a) you need to determine what that IP address is, and b) the IP address may change. If the *DT80* is continuously powered and connected to the network then it will normally retain the same IP address, but if it is unplugged for a period of time then when it is reconnected then it may receive a different address from the DHCP server.

If the logger is nearby then this is not a huge problem because you can determine the IP address via the front panel display, or by making a direct USB connection.

If, however, the logger is remote then it is much more convenient if the IP address is fixed. Similarly, if you plan to allow access to the *DT80* via the Internet then it will need a static IP address.

Note that the *DT80* does not currently support web-based dynamic DNS services such as **dynDNS.com**.

Direct Connection to PC – Automatic IP address

1. Check that Ethernet port is enabled

Using the front panel UP and DOWN keys, select the **Ethernet IP** screen. It should show:

```
Eth IP:     Auto
No cable
```

If this is not the case then the *DT80*'s Ethernet port has been disabled or set to a static IP address. Connect to the logger using a USB or serial connection and enter:

```
PROFILE ETHERNET ENABLE=YES
PROFILE ETHERNET IP_ADDRESS=AUTO
```

Verify that the display is now correct.

2. Connect Ethernet cable

You can now connect a cross-over Ethernet cable between the *DT80* and the computer. Verify that the green Link LED on the *DT80*'s Ethernet connector comes on. If the Link LED does not come on then check that:

- the cable is a correctly wired cross-over cable
- the computer's Ethernet port is enabled (check "Network Connections" in Windows control panel)

3. Check *DT80* IP address

When the Ethernet cable is connected, the *DT80* will begin searching for a DHCP server. When connected directly to a PC, there will normally be no DHCP server available, so after 10 seconds or so the *DT80* will give up and assign itself an "Auto-IP" address. The **Ethernet IP** screen will then change to something like:

```
Eth IP:     Auto
169.254.25.77
```

If you have a DT81 (which has no front panel display) then you can alternatively send the command:

```
IP
169.254.25.77
```

4. Wait for Windows to acquire IP address

Meanwhile, Windows will also be looking for a DHCP server. During this time you may notice an animated icon in the system tray, which, for Windows XP, will look something like the following:

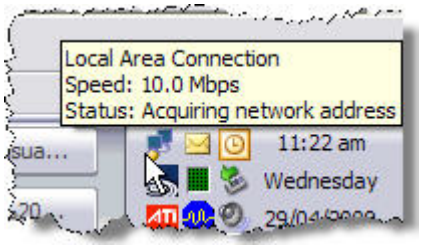


Figure 68: Windows XP searching for a DHCP server

Windows normally spends about 60 seconds looking for a DHCP server, then it, like the *DT80*, will give up and assign itself an Auto-IP address, at which point the system tray icon will disappear.

A message may be displayed at this point warning that the network connection has "limited or no connectivity". This is normal, and simply indicates that the Internet will not be accessible using this network connection.

5. Test the connection

You should now be able to connect to the *DT80*. For example, you could enter the *DT80*'s IP address (169.254.25.77 in the above example) into a web browser in order to access the *DT80*'s web interface, or you could create a TCP/IP connection in *DeTransfer* or *DeLogger*, again specifying the *DT80*'s IP address (see *Using the Network Command Interface* (P188)).

Network Connection – Automatic IP address

The procedure for connecting to an existing LAN using automatic configuration is very similar to the above "direct connection" scenario:

1. Check Ethernet port

As for the direct connection scenario, check that the display indicates **Eth IP: Auto**. If not then enable the port, as described above.

2. Connect Ethernet cable

You can now connect a standard Ethernet cable between the *DT80* and a network connection point. This might be a wall socket connected to an office LAN, or a port on a desktop Ethernet switch or router unit.

Verify that the green Link LED comes on on the *DT80*'s Ethernet connector. If the Link LED does not come on then check that:

- the cable is a correctly wired straight through cable
- the network access point is active (check with your network administrator)

3. Check *DT80* IP address

When the Ethernet cable is connected, the *DT80* will begin searching for a DHCP server. Within a few seconds it should receive an IP address and the **Ethernet IP** screen will then change to something like:

```
Eth IP:     Auto
192.168.11.25
```

If you have a DT81 then you can alternatively send the command:

```
IP
192.168.11.25
```

If the indicated address begins with `169.254` then this indicates that a DHCP server could not be found, so the *DT80* has reverted to an Auto-IP address. This will still work, provided that all other devices on the LAN are also using Auto-IP addresses (see Step 4 below). If, however, the other computers on the network have been set up with static IP address then the *DT80* will need to use a static IP address too (see *Network Connection – Static IP address* (P185)).

Note If no DHCP server was found, the *DT80* will continue to check for one periodically (every 10 seconds at first, then every 5 minutes). If a DHCP server becomes available then the *DT80* will switch over to the IP address supplied by the server.

4. Check Windows IP address

It is now advisable to verify the IP address of the computer that you want to use to communicate with the *DT80*. One way to do this is to open a command prompt window and use the **ipconfig** command. The following response would be typical for an office LAN:

```
C:\>ipconfig

Ethernet adapter Local Area Connection:

      Connection-specific DNS Suffix  . : megacorp.com
      IP Address. . . . . . . . . . . . : 192.168.11.44
      Subnet Mask . . . . . . . . . . . : 255.255.255.0
      Default Gateway . . . . . . . . . : 192.168.11.250
```

In this case note that both the PC and the *DT80* are connected to the same subnet – their IP addresses both start with 192.168.11. This may not necessarily be the case, as there may be a router (or indeed the Internet) between the *DT80* and the computer. This should not be a problem provided that both the *DT80* and the computer have a valid "gateway" set.

A response similar to the following indicates that the computer is using an Auto-IP address:

```
C:\>ipconfig

Ethernet adapter Local Area Connection:

      Connection-specific DNS Suffix  . :
      Autoconfiguration IP Address. . . : 169.254.178.139
      Subnet Mask . . . . . . . . . . . : 255.255.0.0
      Default Gateway . . . . . . . . . :
```

In this case the computer will only be able to communicate with a *DT80* on the same subnet, e.g. one plugged into the same Ethernet switch.

5. Test the connection

You should now be able to connect to the *DT80*. For example, you could enter the *DT80*'s IP address into a web browser in order to access the *DT80*'s web interface, or you could create a TCP/IP connection in *DeTransfer*, again specifying the *DT80*'s IP address (see *Using the Network Command Interface* (P188)).

Network Connection – Static IP address

When connecting the *DT80* to an existing Ethernet network using a static IP address, you need to be a little more careful. Setting the *DT80* to an inappropriate IP address can severely disrupt the operation of the network.

By far the preferred approach here is to ask your network administrator what you should set the *DT80*'s IP address, subnet mask and gateway to (and which outlet you should connect the Ethernet cable to). You can then simply enter the required profile settings (using a USB or serial connection) as described in *Setting Ethernet Parameters* (P182), connect the *DT80*'s Ethernet cable, and you are ready to test the connection.

If you don't have a "network administrator", then the following general procedure can be used

1. Determine subnet details

The first step is to determine the IP address range in use on the subnet, and the gateway address. This can be done using the **ipconfig** command. This should be entered on a computer that is connected to the subnet to which you want to connect the *DT80* (i.e. one that is connected to the same Ethernet switch). It is assumed that this computer's network settings are already correctly configured.

```
C:\>ipconfig /all
...
Ethernet adapter Local Area Connection:

      Connection-specific DNS Suffix  . : megacorp.com
      Description . . . . . . . . . . . : NETGEAR GA311 Gigabit Adapter
      Physical Address. . . . . . . . . : 00-1B-2F-28-77-BB
      Dhcp Enabled. . . . . . . . . . . : Yes
      Autoconfiguration Enabled . . . . : Yes
      IP Address. . . . . . . . . . . . : 192.168.11.44
      Subnet Mask . . . . . . . . . . . : 255.255.255.0
      Default Gateway . . . . . . . . . : 192.168.11.250
      DHCP Server . . . . . . . . . . . : 192.168.10.100
      DNS Servers . . . . . . . . . . . : 192.168.10.100
                                          192.168.10.111
...
```

In this case the subnet mask is 255.255.255.0, which indicates that the first three parts of the IP address (192.168.11) identify the subnet, while the last part identifies an individual computer. IP addresses on this subnet can therefore range from 192.168.11.1 through 192.168.11.254. If, on the other hand, the subnet mask was 255.255.0.0 then the subnet number is given by the first two parts of the address. Such a subnet could then contain IP addresses ranging from 192.168.1.1 through 192.168.254.254. If the subnet mask is something other than these then it becomes a little technical and you should ask an IP expert.

You should also make a note of the **Default Gateway** address (192.168.11.250 in this case) and the **DNS Server** addresses (192.168.10.100 and 192.168.10.111).

2. Select *DT80* IP address

The IP address chosen for the *DT80* must:

- have the correct subnet number, as determined above. In this example, the subnet number is 192.168.11.
- have a unique host number. So in this example the *DT80* could not use the host number "44" (i.e. have an IP address of 192.168.11.44), because that has already been taken by the host computer.

This is where it can get tricky. One method of finding a free address is to "ping" various IP addresses to see whether there is any reply. Be aware that this is not foolproof, but it may be adequate for a small network where you are aware of all the devices that use it. The procedure is as follows:

1. Switch on all computers and devices that are connected to the network in question and allow them to boot up.
2. From the command prompt window, use the **ping** utility to test a candidate IP address, e.g.:
   ```
   ping 192.168.11.10
   ```
3. If you see a `Reply from 192.168.11.10`... response then that address is not free and cannot be used for the *DT80*.
4. If you see a `Request timed out`... response then the address can probably be used for the *DT80*.

3. Configure the *DT80*

You now have all the information you need and can proceed to configuring the *DT80*. Connect to the *DT80* using a USB or RS232 connection and enter the appropriate profile settings. For this example (assuming that IP address 192.168.11.10 passed the ping test) you would enter:

```
PROFILE ETHERNET ENABLE=YES
PROFILE ETHERNET IP_ADDRESS=192.168.11.10
PROFILE ETHERNET SUBNET_MASK=255.255.255.0
PROFILE ETHERNET GATEWAY=192.168.11.250
PROFILE NETWORK DNS_SERVER_1=192.168.10.100
PROFILE NETWORK DNS_SERVER_2=192.168.10.111
```

4. Check Ethernet port

Using the front panel UP and DOWN keys, select the **Ethernet IP** screen. It should show the configured IP address:

```
Eth IP: No cable
192.168.11.10
```

If this is not the case then the *DT80*'s Ethernet port has not been properly configured, see Step 3 above.

5. Connect Ethernet cable

You can now connect a standard Ethernet cable between the *DT80* and a network connection point. Verify that the green Link LED comes on on the *DT80*'s Ethernet connector. If the Link LED does not come on then check that:

- the cable is a correctly wired straight through cable
- the network access point is active (check with your network administrator)

6. Check *DT80* IP address

When the Ethernet cable is connected, the `No cable` indication should disappear from the **Ethernet IP** screen:

```
Eth IP:    Manual
192.168.11.10
```

If you have a DT81 then you can alternatively send the command:

```
IP
192.168.11.10
```

7. Test the connection

You should now be able to connect to the *DT80*. For example, you could enter the *DT80*'s IP address (192.168.11.10 in this case) into a web browser in order to access the *DT80*'s web interface, or you could create a TCP/IP connection in *DeTransfer* or *DeLogger*, again specifying the *DT80*'s IP address (see *Using the Network Command Interface* (P188)).

Accessing the *DT80* via the Internet

One of the major advantages connecting to the *DT80* via its Ethernet port is that you can then potentially access the *DT80* from anywhere in the world via the Internet. That is, you use your computer and its existing Internet connection to access the *DT80* in much the same way as you would access a web site. This section discusses what is required in order to make this happen.

There are essentially two possible connection scenarios:

- The *DT80* is on a private network, "behind" a NAT (Network Address Translation) router or firewall. This private network may be a corporate LAN (*Figure 66* (P181)), or a single cable between the *DT80* and an integrated modem-gateway (*Figure 67* (P181)).
- The *DT80* is connected to the Internet directly, or via a conventional (non-NAT) router.

DT80 *on Private Network*

Figure 66 (P181) shows a typical network arrangement where the *DT80* is on a private LAN. In this case the *DT80* has been configured with a static private IP address, 192.168.1.7, as described in *Network Connection – Static IP address* (P185).

In this example, the organisation's ISP has allocated a single public IP address (203.54.192.12) which is "shared" by PC1, PC2, the *DT80* and any other devices on the local network. As far as the outside world is concerned, the whole network looks like one single computer with one IP address. The NAT router is responsible for maintaining this fiction – it does this by remembering which local computer made a given request (e.g. to view a particular web page) and making sure that when the matching reply from the Internet is received (containing the web page itself), then it is forwarded to the correct computer.

Port Forwarding

The *DT80*, however, is acting primarily as a server. It does not initiate requests; it sits there and waits for incoming web or FTP or command interface requests, then processes them.

It is therefore necessary to tell the NAT router (firewall) to forward such requests to the *DT80*'s IP address. Otherwise, the router will not know what do with these requests, and simply discard them.

This process is known as **port forwarding**. You (or your network administrator) will need to configure the router so that incoming requests using the following TCP/IP ports will be forwarded to the *DT80*'s IP address:

- TCP port 80 – allows access to the *DT80*'s web server
- TCP port 21 – allows access to the *DT80*'s FTP server (command port)
- TCP ports 1024-5000 – allows access to the *DT80*'s FTP server (data port). For "passive mode" FTP transfers, the *DT80* randomly selects a data port from this range.

- TCP port 7700 – allows access to the *DT80*'s command interface server
- TCP port 843 – allows access to the *DT80*'s enhanced web interface
- TCP port 502 – allows access to the *DT80*'s Modbus server
- ICMP (Internet Control Message Protocol) – allows "ping" requests to be sent to the *DT80*; this can be helpful when diagnosing network problems

The actual procedure for doing this will vary according to the particular model of router/firewall. Consult the unit's documentation for more details.

(Note that the above port numbers listed above are the defaults. Some of these can be changed in the *DT80* profile, see *Profile Settings* (P204).)

Note You should only enable port forwarding for *DT80* facilities that you wish to make available to the Internet. For example, if you want to prevent any access to the *DT80* command server then you should not set up port forwarding for port 7700.

Once the NAT router has been set up to forward the required ports, you should now be able to access the *DT80* from outside the local network using the network's public IP address. So in this example, you could enter **http://203.54.192.12** into a web browser and you should see the *DT80* web interface.

Note The public IP address (203.54.192.12) should only be used from computers outside the local network. If you wanted to access the *DT80* from PC1 or PC2 you would still use the *DT80*'s private address, 192.168.1.7.

Adding a DNS Entry

It is customary (although not essential) to set up a **Domain Name System (DNS)** entry for an Internet-accessible *DT80*. This allows you to associate a meaningful name, e.g. **mydt80.gigadata.com**, with the *DT80*'s public IP address, so users can just type in the name without having to remember the actual IP address.

Depending on the structure of the local network, this may involve configuring the local DNS server (if any) and/or requesting that the ISP add an entry to its DNS server. For more details, contact your network administrator or ISP.

Direct Internet Connection

The other possible configuration is where the *DT80* is essentially connected directly to the Internet. A typical setup is shown in *Figure 69* below.

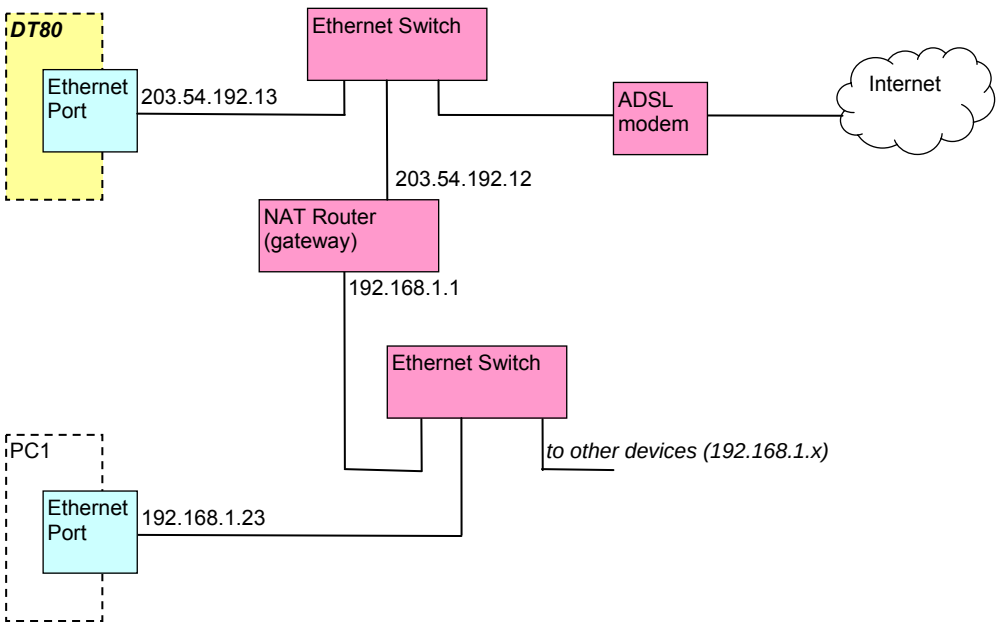


Figure 69: Typical Ethernet LAN with DT80 *directly connected to the Internet*

In this case two public IP addresses have been allocated by the ISP – one (203.54.192.13) for the *DT80* and one (203.54.192.12) for everything else, via the NAT router.

Because the *DT80* is now effectively directly connected to the ISP's network, its IP address, subnet mask, gateway and DNS server addresses will need to be set up using values provided by the ISP.

Once the *DT80*'s network profile settings have been set it should be possible to connect to it from either a local computer (e.g. PC1) or a remote system on the Internet, using its unique public IP address (203.54.192.13).

Note that in this case port forwarding is not required, as requests for the *DT80* no longer pass through the NAT router.

If desired, you can request that your ISP set up a DNS entry so that the *DT80* can be referred to by name, e.g. **mydt80.nanodata.com**.

Using the Network Command Interface

Connecting

To access the *DT80*'s command interface over Ethernet you need to use a terminal program on the host computer that can send/receive text to a TCP port. *DeTransfer* and *DeLogger* support this. By default, **TCP Port 7700** is used; this can be changed in the *DT80* profile if required.

Using *DeTransfer*, for example, you first need to set up a **connection**. This is the same as setting up a connection for RS232 or USB, except that instead of specifying a COM port number, you now need to specify an IP address. The following screen shot illustrates this.

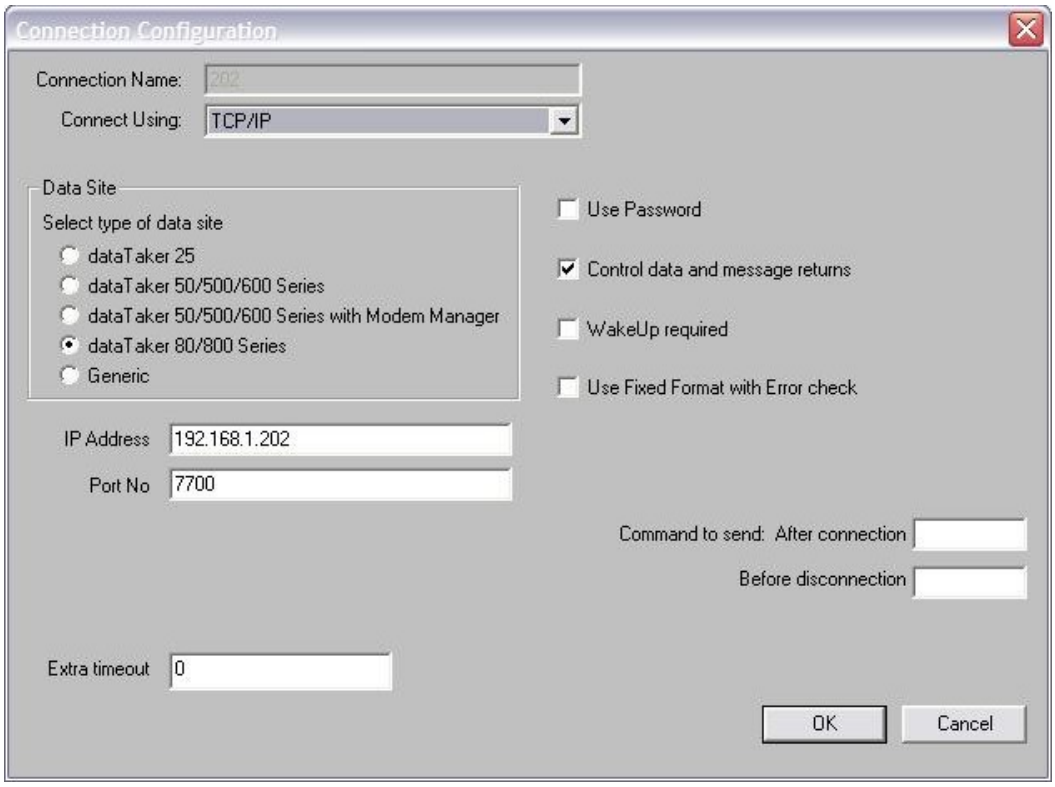


Figure 70: Example software connection for a DT80 on an Ethernet network (DeTransfer software shown)

Note When creating a new connection the current version of *DeTransfer* defaults to Port 8. It must therefore be explicitly set to Port 7700.

If you now press Connect, you should be able to send commands to the *DT80* and receive data, just as you would using USB or RS232.

Multiple Connections

Up to ten client computers (or ten *DeTransfer* sessions on the one computer) can simultaneously connect to the *DT80* command interface using the TCP/IP network. This is in addition to a possible USB and/or RS232 connection.

At any one time, only one of these interfaces/sessions can be the **active** interface. The active interface is the one on which the most recent *DT80* command was sent.

Whenever the *DT80* transmits something over the command interface (e.g. returned/unloaded data, prompt strings, messages, etc.), it is send to the current active interface, plus all connected TCP/IP sessions. This provides a way to "broadcast" data to a number of different computers, each of which operates as a passive listener.

Disconnecting

It is important to note that all Ethernet sessions will be disconnected if the *DT80*:

- undergoes a hard reset (**HRESET**, manual reset or power failure)
- enters low power sleep mode.

For this reason, the *DT80* normally disables sleep mode while an Ethernet cable is connected (although this can be overridden by setting P15 to 3 or 4.

If an Ethernet session is disconnected in this way, you may need to manually disconnect then reconnect in *DeTransfer*.

Using the *DT80* FTP Server

The *DT80* can also function as an FTP (File Transfer Protocol) server. You can use this mechanism to transfer data and program files to and from the *DT80*. This is done by running an **FTP client** application on the host computer and using it to

connect to the *DT80*'s **FTP server** (by specifying the *DT80*'s IP address).

Passwords

The FTP server supports two types of access:

- an anonymous login (username **ANONYMOUS**, password can be anything) provides **read-only** access to the *DT80*'s file system.
- a full login (using the username and password configured in the *DT80* profile) provides **read/write** access.

To set the FTP password, use the following profile commands:

```
PROFILE FTP_SERVER USER=DT
PROFILE FTP_SERVER PASSWORD=TOPSECRET
```

If, for security reasons, you want to disable the FTP server altogether, enter:

```
PROFILE FTP_SERVER SUPPORTED=NO
```

You can also disable anonymous logins, using:

```
PROFILE FTP_SERVER ALLOW_ANONYMOUS=NO
```

FTP Client Software

A Windows computer includes at least two different FTP clients that can be used to access the *DT80*'s file system. You can run the traditional command-line version by typing

`ftp` *ip-address*

in a command prompt window (*ip-address* is the IP address of the *DT80*).

Alternatively, most web browsers will allow you to browse the *DT80* by entering the following URL:

`ftp://`*user*`:`*password*`@`*ip-address*`/`*drive*`:/`, or

`ftp://`*ip-address*`/`*drive*`:/` (for anonymous read-only access)

where:

- *user* and *password* are the username and password to use.
- *ip-address* is the *DT80*'s IP address
- *drive* is the *DT80* drive to browse (`A` or `B`).

The browser should then present a list of available files and folders, through which you can navigate simply by clicking on links.

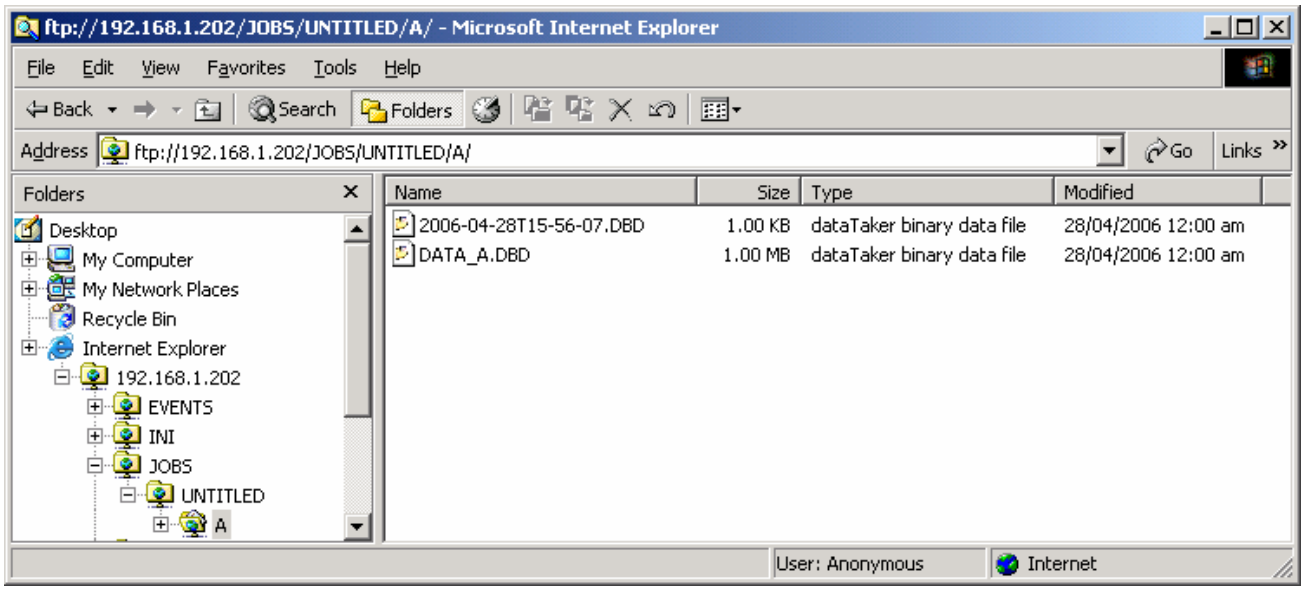


Figure 71: Typical file display when connected to DT80 *FTP server*

In order to load a file onto the *DT80*, or delete a file, you will need to:

- use a true FTP client, as opposed to a web browser. Windows Explorer (not Internet Explorer), or the command line client are suitable, or there are numerous others available.
- specify the configured username and password as set in the profile. For example, with the default settings you could enter the following into the Windows Explorer address bar:
  `ftp://DATATAKER:DATATAKER@192.168.1.202/B:/`
  and then if you drag files into it then they should be uploaded to the logger.

Troubleshooting

If you experience problems connecting to the *DT80* FTP server, it can be helpful to examine the raw FTP messages that are being exchanged. To enable display of received and transmitted FTP messages, set **P56=8**. For example:

```
P56=8
>> 220  dataTaker FTP Server ready. Type HELP for help
<< USER anonymous
>> 331 User name okay, need password.

<< PASS IEUser@
>> 230 User logged in, proceed.

<< syst
>> 215 UNIX Type: L8

<< PWD
>> 257 "/" is current directory.

<< CWD \b:\
>> 250 Requested file action okay, completed.

<< TYPE A
>> 200 Command okay.

<< PASV
>> 227 Entering Passive Mode (192,168,1,202,14,183)

<< LIST
>> 150 File status okay; about to open data connection.

>> 226 Closing data connection. Transfer succeeded
```

This shows an anonymous user logging in and requesting a directory listing. Lines beginning with << were received by the *DT80*, while >> indicates lines that were transmitted by the *DT80*.

Note that this setting will also show exchanges between the *DT80* and an external FTP server – for example when unloading or copying archive files to an FTP server (see *Retrieving Logged Data* *(P90)*).

PPP Communications

About PPP

Point-to-Point Protocol (PPP) allows TCP/IP-based protocols to be run over the USB, Host RS-232 and/or serial sensor port of the *DT80*.

A client computer can connect to the *DT80*, via modem or direct cable, in much the same was connecting to a dial-up Internet Service Provider. (Modem connections are only supported on the host RS232 port.) When a PPP connection is made, the *DT80* will, like an ISP, verify the supplied username and password and allocate an IP address for the host PC to use for the duration of the session.

Each of the *DT80*'s three PPP-capable ports has its own IP address, which is in turn different to the IP address for the Ethernet port. This means that TCP/IP can potentially be active on all four ports simultaneously.

Note For the USB port, the dataTaker ***DtUsb*** driver software is used to set up and manage a PPP connection in a simple manner. See *USB Port* *(P162)* for more details. There is no need for any of the PPP configuration described in this section if you are using the USB port. This section is, however, still applicable if you plan to use a direct RS232 or modem connection.

Setting up PPP

Setting up a PPP connection involves four main steps:

1. Set or verify the required profile settings on the *DT80*
2. Install the physical communications link (RS232 cable, modem etc.)
3. Define a "modem device" on the host computer to represent the physical comms link.
4. Define a PPP "network connection" on the host computer, which will use the defined modem device.

This normally needs to be done once only. Once the PPP network connection has been set up and saved on the host computer, you can then establish a connection as and when required. This process is the same as you would use when connecting to an Internet Service Provider via a dial-up connection. See *Using PPP* *(P198)*.

1. DT80 *Profile Settings*

PPP Settings

The *DT80*'s PPP settings can be listed using the **PROFILE** command:

```
PROFILE PPP
[PPP]
   SERSEN_IP_ADDRESS = 1.0.0.1
   SERSEN_REMOTE_IP_ADDRESS = 1.0.1.1
   HOST_IP_ADDRESS = 1.0.0.2
   HOST_REMOTE_IP_ADDRESS = 1.0.1.2
   USB_IP_ADDRESS = 1.0.0.3
   USB_REMOTE_IP_ADDRESS = 1.0.1.3
   USER = ANONYMOUS
   PASSWORD = PASSWORD
```

These show:

- the *DT80*'s IP address for each of the three serial ports. For example, if you establish a PPP connection to the host RS232 port then by default the *DT80*'s IP address would be 1.0.0.2. You could therefore access the *DT80*'s web interface by entering **http://1.0.0.2** into a web browser, for example.
- the IP address that the *DT80* will allocate to the host PC, for each of the three serial ports. So for an RS232 PPP connection the host computer's IP address would be 1.0.1.2.
- the username and password that the host computer must supply when establishing a PPP connection.

These profile settings can be changed in the usual way, e.g.

```
PROFILE PPP USER=DT
PROFILE PPP PASSWORD=SECRET
```

There is normally no need to change any of the IP address settings.

Comms Port Settings

The settings for the desired *DT80* port will also need to be set or checked. For example, if the host RS232 port is used then the current settings can be queried using:

```
PROFILE HOST_PORT
[HOST_PORT]
   BPS = 57600
   DATA_BITS = 8
   STOP_BITS = 1
   PARITY = NONE
  *FLOW = HARDWARE
   FUNCTION = COMMAND
```

In order for the port to support PPP, the **FUNCTION** parameter must be set to **COMMAND** or **PPP**:

- The **COMMAND** setting (which is the default for USB and host RS232 ports) means that the port supports both the regular command interface and PPP, automatically switching between the two when a PPP connection is established and disconnected.
- The **PPP** setting only allows PPP connections on the port. This provides improved security, especially on modem links, as a valid username and password must be supplied before a PPP connection can be established.

For the host and serial sensor RS232 ports, the flow control should be set to **HARDWARE** (RTS/CTS). Software flow control is not recommended for PPP.

For RS232 ports, also make a note of the baud rate and framing settings – these will be needed when setting up the host PC end of the connection.

2. Install the Physical Communications Link

The physical communications link over which PPP is to be run should now be installed. This link might be

- a null modem (cross-over) RS232 cable, connected between the *DT80* host RS232 or serial sensor port and a PC RS232 port (or USB to RS232 adapter). For the serial sensor port, RS422/485 may also be used, with an appropriate adapter at the PC end.
- a modem (dial-up, radio, cellular), connected to the *DT80* host RS232 port, with another internal or external modem connected to the host computer.

You now need to determine the PC COM port. This can be done by attempting to establish a standard command interface connection, using *DeTransfer* or *DeLogger*. Refer to *USB Port* *(P162)*, *RS-232 Communications* *(P168)* or *Modem Communications* *(P174)* for more details. (Note that this will not work if the *DT80* port function has been be set to **PPP**. Set it to **COMMAND** for this test.)

Once you have verified that a connection can be established, be sure to close the connection in *DeTransfer*. Make a note of the COM port number.

3. Install the Windows Modem Device

It is now necessary to set up the "modem device" that Windows will use for communicating over this link. This is done as follows. Be sure that the cable or modem is plugged in to the host computer before proceeding.

Note When using Windows Vista, note that at various points during this process you may see "Windows needs your permission" messages. Click **Continue** in each case.

1. Open the Windows **Control Panel**.
2. Open the **Phone and Modems Options** item. This may be listed under the **Printers and Other Hardware** (XP) or **Hardware and Sound** (Vista) category.
3. If the **Dialling Rules** dialog is displayed, ensure that a valid area code is entered.
4. Once the area code has been set, select the **Modems** tab:

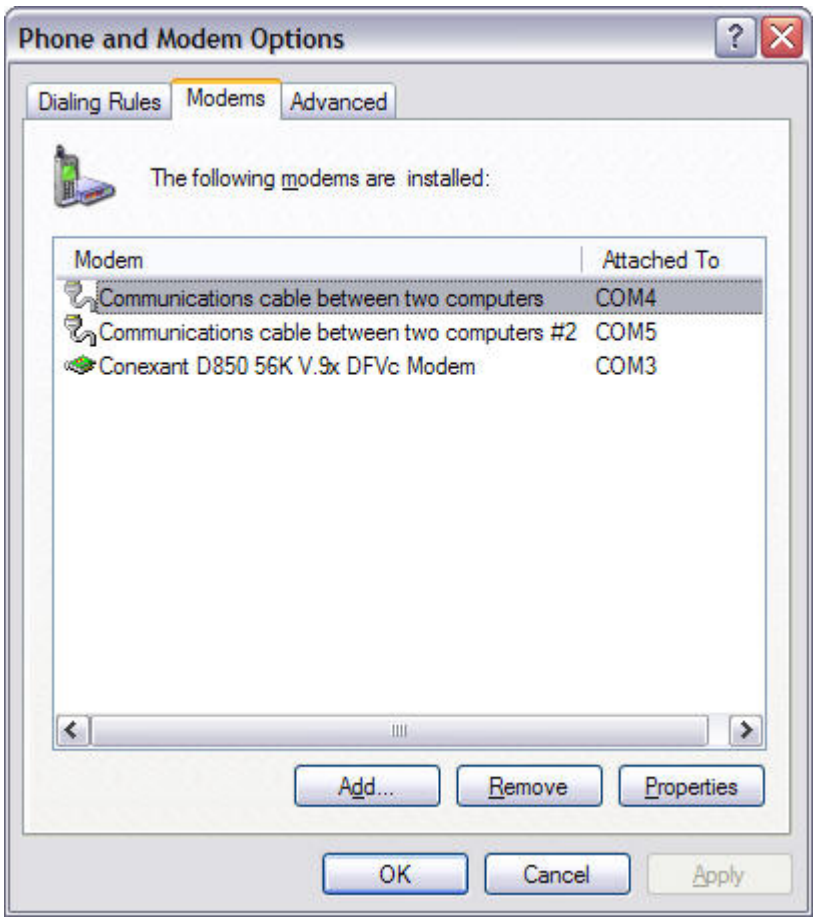


Figure 72: List of installed modem devices (Windows XP)

This dialog shows all currently installed modem devices. In the above example the computer's internal dial-up modem is shown (COM3), along with two null modem cables (which, as far as the computer is concerned, are still "modems"). In this case it so happens that the COM4 null modem cable is an RS232 cable, while COM5 is a USB cable – although this is not apparent in this dialog.

5. If the modem (or null modem cable) that you intend to use for PPP is not listed, then you will need to add it, using the **Add** button. This will launch the Windows **Add Hardware Wizard**.
   a) If you are using a direct USB or RS232 null modem cable then tick the **Don't detect modem; I will select it from a list** option. (If you are using a modem then you can leave this unticked; Windows will then attempt to automatically detect it. If this fails then you will need to select the modem type from a list, in the next step.)
   b) You should now see a list of different modem types. If you are using a direct USB or RS232 null modem cable then select the first one in the list, **Communications cable between two computers**.
   c) Select the correct COM port number from the list. If the required COM port number is not listed then double check that you have closed any connections using that port in *DeTransfer* or *DeLogger*.
   d) The modem device should now have been added, and you will be returned to the modem list screen (*Figure 72*). Verify that the newly added modem device is now present.
6. If a direct RS232 cable is being used then one further step is required. This is not necessary for a direct USB or modem connection.
   a) Select the RS232 cable from the list of modem devices and click **Properties**.
   b) Select the **Modem** tab and set the **Maximum Port Speed** field equal to the configured baud rate on the *DT80*, then press **OK**.

The final step is to define a Windows "network connection" using the **Network Connection Wizard**. This process varies

depending on whether a direct cable or modem connection is used.

4a. PPP Network – Direct Cable Connection

This section describes the process of creating a Windows "network connection", when using a direct USB or RS232 cable connection. If you are using a modem, see *4b. PPP Network – Modem Connection* (P195).

The following is applicable to Windows XP

1. From the Start menu, select **Connect to**, then **Show all connections**. This will display a list of currently defined network connections (if any).
2. Select the **New Connection Wizard**, or the **Create a new connection** task. This will start the Network Connection Wizard.
3. Select **Setup an advanced Connection**.
4. Select the option to **Connect directly to another computer**.
5. Specify that you are setting up a **Guest** connection
6. Enter a name for the connection, e.g. "DT80 USB ppp"
7. Select the appropriate "Communications cable between two computers" modem device from the list.
8. Specify whether you want the connection to be available just for your Windows user name, or for anyone who uses the computer.
9. Complete the wizard by specifying whether or not you would like it to create a desktop icon for the connection. (A desktop icon allows you to establish the PPP connection simply by double clicking on the icon.)
10. The wizard will now display the **Connect** dialog. (*Figure 73;* you will see this dialog each time you establish a PPP connection to the logger.) Press **Cancel** for now. A few more options should be set before connecting, as detailed below.

The following is applicable to Windows Vista

1. From the Start menu, select **Connect to**. This will display a list of currently defined network connections (if any).
2. Select **Setup a connection or network**. This will start the Network Connection Wizard.
3. Select **Setup a dial-up connection**.
4. If more there is more than one "modem device" installed then you will be asked to select which one you want to use. Select the appropriate "Communications cable between two computers" from the list.
5. You will now be prompted for your ISP connection details (telephone number, username and password). For a direct cable connection the telephone number won't be used so you can enter anything here.

   Enter a name for the connection, e.g. "DT80 USB ppp". The username and password can be left blank for now. Press **Connect**.
6. Windows will now attempt to establish the connection. This will fail, so press **Skip** to skip this step.
7. Windows will report that the connection attempt failed. Select **Setup the connection anyway** to save the connection details.
8. Press **Close**.

Additional Settings

A few further settings are required (these are applicable to both XP and Vista)

1. From the Start menu, select **Connect to**, then select the PPP connection that you just created. If required, press **Connect**.
2. The **Connect** dialog will now be displayed.

Figure 73: PPP Connect dialog (Windows XP)

Enter the username and password specified in the *DT80* profile (by default **ANONYMOUS** and **PASSWORD**, note these are case sensitive), and tick the **Save this username and password** option so you won't have to enter it next time.

Now click **Properties**.

3. The connection properties page will now be displayed. On the **General** tab, click **Configure**.

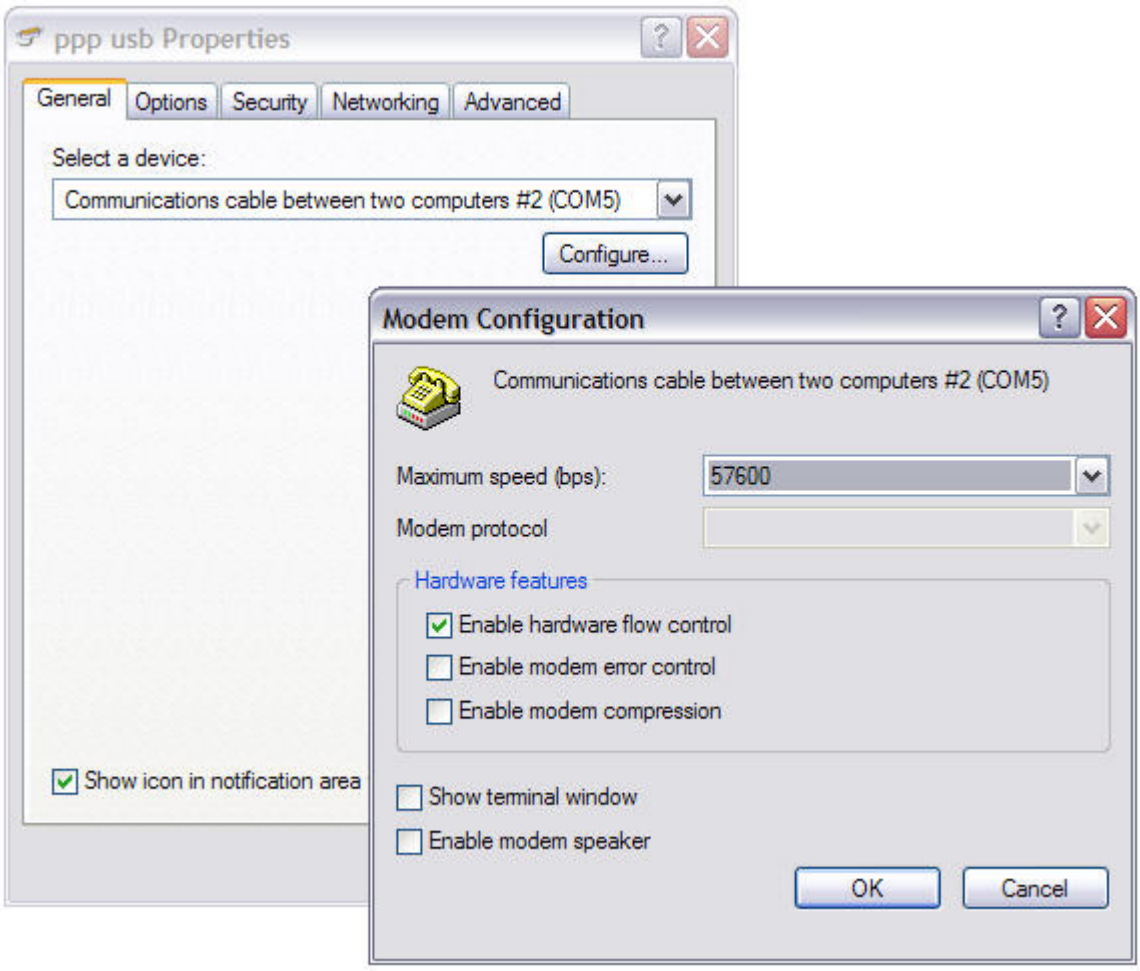


Figure 74: PPP Modem Configuration for direct cable connection (Windows XP)

For a direct RS232 cable connection, ensure that the **Maximum speed** setting is set to the configured baud rate of the

DT80 serial port in use. For a USB connection this setting is irrelevant. Check that the other settings are as shown in *Figure 74*, then press **OK**.

4. On Windows XP, select the **Networking** tab, then press **Settings**. On Windows Vista, select the **Options** tab then press **PPP Settings**. This will display the PPP Settings dialog.

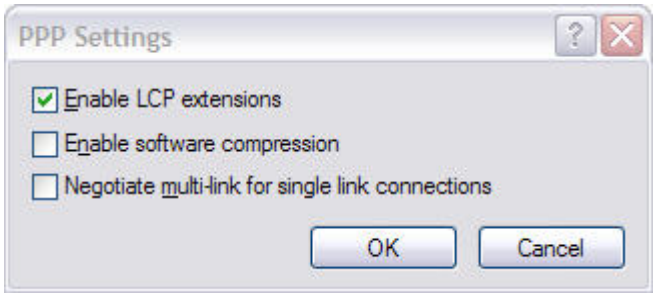


Figure 75: PPP Settings

Set the options as shown. In particular, disable the **Enable software compression** option, then press **OK**. This will reduce the time taken to establish a PPP connection.

5. On the **Networking** tab, select the **Internet Protocol (TCP/IP)** option and then click **Properties**.
6. Click **Advanced** to display the **Advanced TCP/IP Settings** dialog.

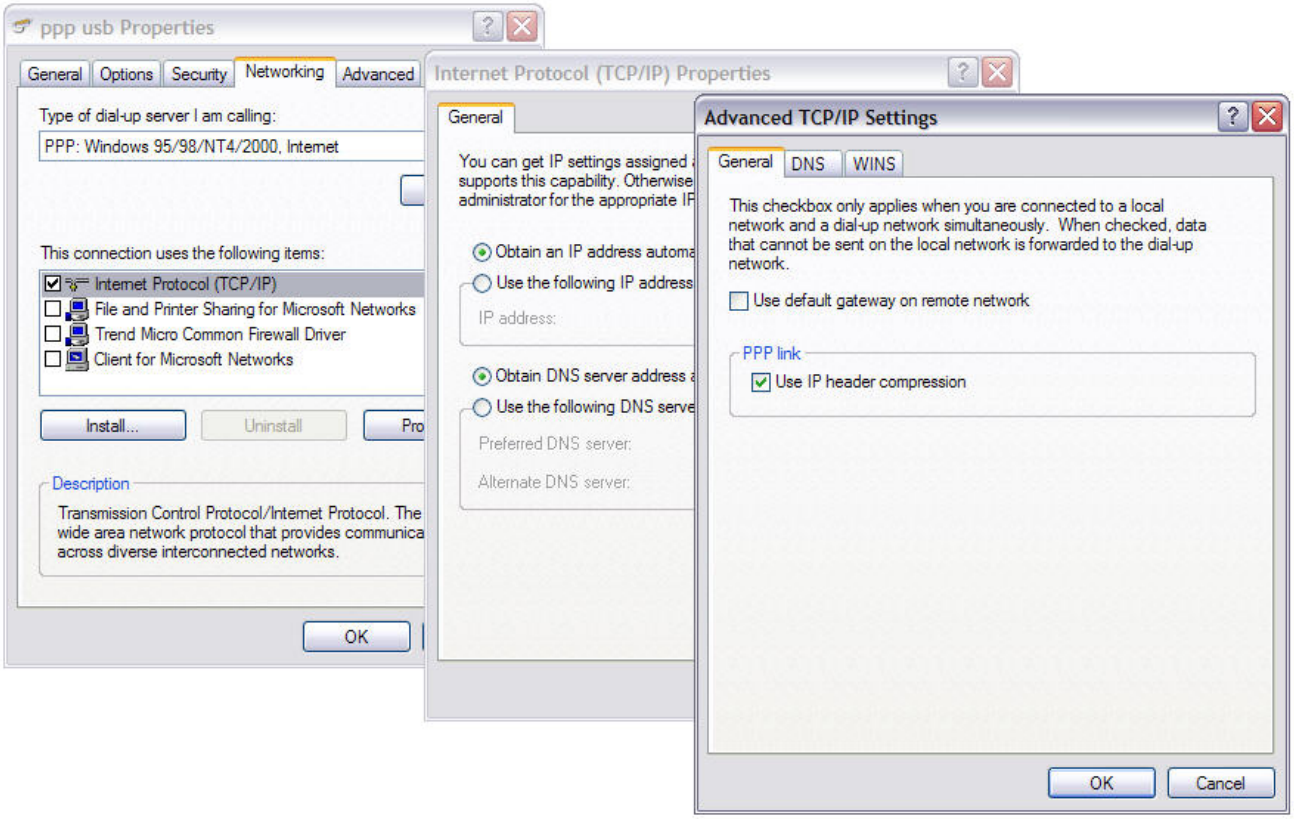

ppp usb Properties
General
Options
Security
Networking
Advanced
Type of dial-up server I am calling:
PPP: Windows 95/98/NT4/2000, Internet
This connection uses the following items:
Internet Protocol (TCP/IP)
File and Printer Sharing for Microsoft Networks
Trend Micro Common Firewall Driver
Client for Microsoft Networks
Install...
Uninstall
Description
Transmission Control Protocol/Internet Protocol. The wide area network protocol that provides communica across diverse interconnected networks.
OK
Internet Protocol (TCP/IP) Properties
General
You can get IP settings assigned supports this capability. Otherwise administrator for the appropriate IP
Obtain an IP address automa
Use the following IP address
IP address:
Obtain DNS server address
Use the following DNS serve
Preferred DNS server:
Alternate DNS server:
Advanced TCP/IP Settings
General
DNS
WINS
This checkbox only applies when you are connected to a local network and a dial-up network simultaneously. When checked, data that cannot be sent on the local network is forwarded to the dial-up network.
Use default gateway on remote network
PPP link
Use IP header compression
OK
Cancel

*Figure 76: TCP/IP Settings – uncheck the **Use Default Gateway** option*

Check the settings against those shown in *Figure 76*. In particular, the **Use default gateway** option should be disabled. If this is not done then Windows will attempt to use the PPP connection as its default Internet connection, the end result being that the Internet will not be accessible from your computer while a PPP connection to the *DT80* is in progress. (If your computer does not have an Internet connection then this step can be ignored.)

7. Press **OK** to close the various "properties" dialogs, and return to the **Connect** dialog (*Figure 73*). You can now try establishing a PPP connection, see *Using PPP* *(P198)*.

4b. PPP Network – Modem Connection

This section describes the process of defining a Windows "network connection" when using a modem connection. It is assumed that an appropriate "modem device" has already been installed, as described in *3. Install the Windows Modem* Device *(P192)*.

The following is applicable to Windows XP

1. From the Start menu, select **Connect to**, then **Show all connections**. This will display a list of currently defined network connections (if any).
2. Select the **New Connection Wizard**, or the **Create a new connection** task. This will start the Network Connection Wizard.

3. Select **Connect to the Internet**.
4. Select **Set up my connection manually**.
5. Select **Connect using a dial-up modem**.
6. When prompted for an "ISP Name", enter a name for the connection, e.g. "DT80 modem ppp"
7. Select which modem you wish to use. If you only have one modem connected then this step will be skipped.
8. Enter the phone number for dialing in to the *DT80* modem.
9. Specify whether you want the connection to be available just for your Windows user name, or for anyone who uses the computer.
10. Enter the username and password specified in the *DT80* profile (by default **ANONYMOUS** and **PASSWORD**, note these are case sensitive).

    Uncheck the **Use this account when anyone connects to the Internet** option.

    Uncheck the **Make this the default internet connection** option.
11. The wizard will now display the **Connect** dialog. (*Figure 73*; you will see this dialog each time you establish a PPP connection to the logger.) Press **Cancel** for now. A few more options should be set before connecting, as detailed below.

The following is applicable to Windows Vista

1. From the Start menu, select **Connect to**. This will display a list of currently defined network connections (if any).
2. Select **Setup a connection or network**. This will start the Network Connection Wizard.
3. Select **Setup a dial-up connection**.
4. If more there is more than one modem installed then you will be asked to select which one you want to use. Select the correct one from the list.
5. You will now be prompted for your ISP connection details (telephone number, username and password).

   Enter the phone number for dialing in to the *DT80* modem.

   Enter the username and password specified in the *DT80* profile (by default **ANONYMOUS** and **PASSWORD**, note these are case sensitive).

   Enter a name for the connection, e.g. "DT80 modem ppp".

   Press **Connect**.
6. Windows will now attempt to establish the connection. This will fail, so press **Skip** to skip this step.
7. Windows will report that the connection attempt failed. Select **Setup the connection anyway** to save the connection details.
8. Press **Close**.

Additional Settings

A few further settings are required (these are applicable to both XP and Vista)

1. From the Start menu, select **Connect to**, then select the PPP connection that you just created. If required, press **Connect**.

   The **Connect** dialog (*Figure 73*) will now be displayed. Click **Properties**.

2. The connection properties page will now be displayed. On the **General** tab, click **Configure**.

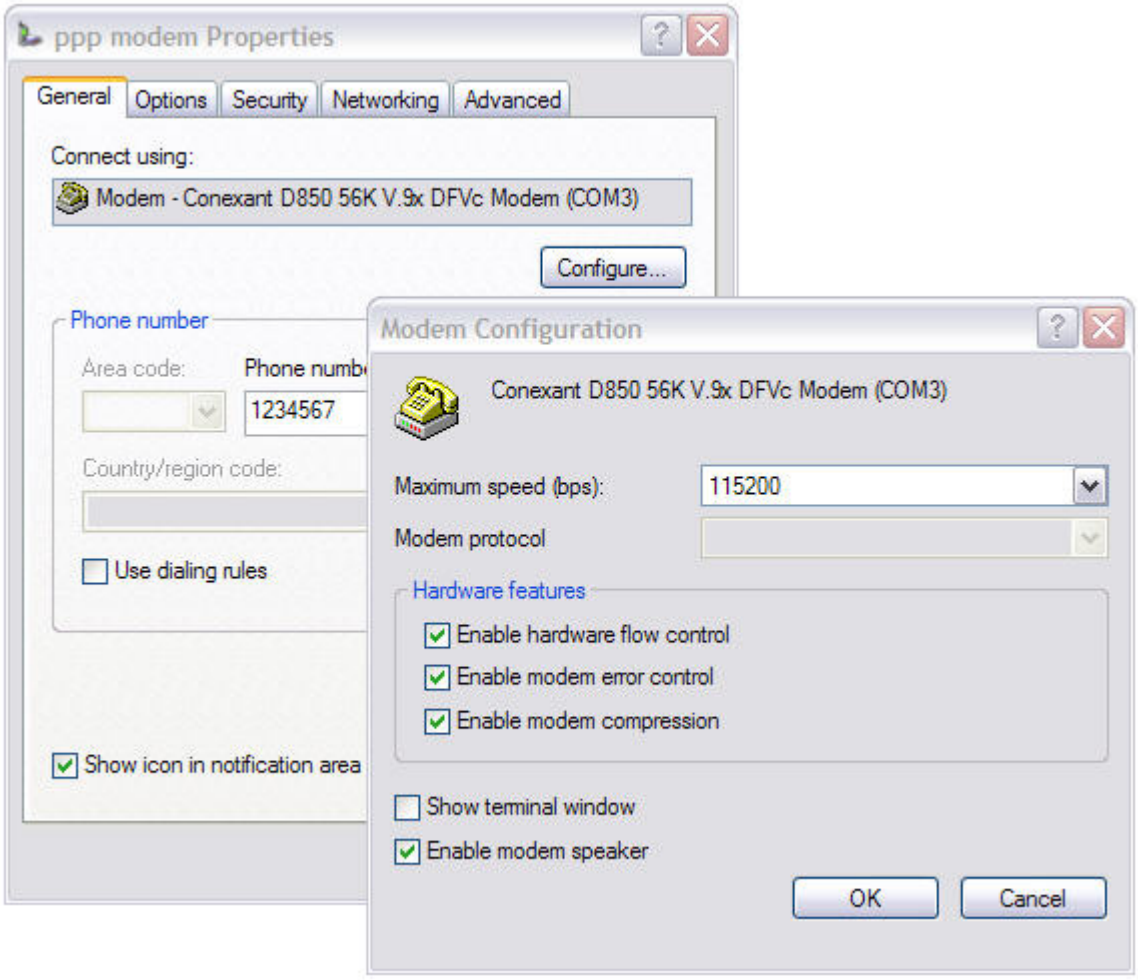


Figure 77: PPP Modem Configuration for modem connection (Windows XP)

For a modem connection, the **Maximum speed** setting should normally be set higher than the modem connect speed (e.g. set to 115200 for a 56kbps modem). Unlike the direct cable connection case, it does not need to match the *DT80* port speed.

The modem error control and compression options should also be enabled. Enabling the modem speaker is optional.

Press **OK**.

3. On Windows XP, select the **Networking** tab, then press **Settings**. On Windows Vista, select the **Options** tab then press **PPP Settings**. This will display the PPP Settings dialog (*Figure 75*). As with the direct connection, disable the **Enable software compression** option, then press **OK**.
4. On the **Networking** tab, select the **Internet Protocol (TCP/IP)** option and then click **Properties**.
5. Click **Advanced** to display the **Advanced TCP/IP Settings** dialog (*Figure 76*). As with the direct connection, the **Use default gateway** option should be disabled to prevent Windows from attempting to use the PPP connection as its default Internet connection.
6. Press **OK** to close the various "properties" dialogs, and return to the **Connect** dialog (*Figure 73*). You can now try establishing a PPP connection, see *Using PPP* (P198).

Using PPP

Once a PPP connection has been set up, the general day to day process for using it is as follows:

1. Ensure that the physical communications link is plugged in (modem or null modem cable).
2. Establish a PPP connection by "dialing up" to the *DT80* (for a direct cable connection no actual "dialling" occurs).
3. After the connection process completes you will be able to access the *DT80* via the configured IP address for the serial port in use. For example, if the host RS232 port is being used then the default IP address is 1.0.0.2.
4. When you have finished, the PPP connection can be disconnected. The *DT80*'s IP address (e.g. 1.0.0.2) will no longer be valid.

See below for more details.

Establishing a Connection

To establish a connection:

1. Select **Connect To** on the Windows Start menu, then select the "network connection" that you created for the PPP link.
2. The **Connect** dialog (*Figure 73*) will be displayed. Press **Connect**.
3. If all goes well, a few status messages will be displayed briefly as Windows establishes the physical connection, logs in to the *DT80*, and then adds the *DT80*'s IP address to its networking configuration.
4. By default, an icon representing the PPP connection will now be displayed in the Windows system tray:

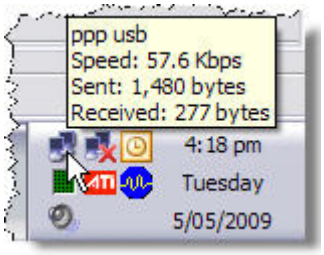


Figure 78: System tray icon for an active PPP connection (Windows XP)

Note that for a USB connection, the indicated "speed" is irrelevant. USB always operates at a fixed rate.

Using the Connection

Once the connection has been established, you can access the *DT80* in much the same way as you would using an Ethernet connection. By default, the IP addresses for the three *DT80* serial ports are:

- **1.0.0.1** for the serial sensor port
- **1.0.0.2** for the host RS232 port
- **1.0.0.3** for the USB port

The appropriate IP address can then be entered into a web browser, or FTP client, or *DeTransfer/DeLogger*, etc.

The IP address of the host computer at the other end of the PP link is as above but with a 1 rather than a 0 in the second last position. So for a host RS232 PPP connection the *DT80*'s IP address is 1.0.0.2, and the host computer's IP address is 1.0.1.2.

Limitations

It is important to note that a PPP connection provides connectivity between the *DT80* and a single host computer only. The PPP "network" linking the computer and the *DT80* is a private network and is not visible to any other computers.

If you wish to unload logged data to an FTP server via a PPP then the FTP server must be running on the host computer itself. You could then perform the unload using a *DT80* command such as:

```
COPYD dest=ftp://anonymous:a@1.0.1.2/mydata/
```

It is not possible to unload to an FTP server on the Internet via a PPP connection. For that you need an Ethernet connection.

Closing a Connection

To terminate a PPP session, simply right click on the connection's system tray icon and select **Disconnect**. Alternatively, use **Connect To** to bring up the list of all defined network connections, then right click on the appropriate connection and select **Disconnect**.

You can also end a PPP session by sending the *DT80* command **CLOSEDIRECTPPP**. By default, this command will close all currently active PPP connections. To close a connection on one particular port, specify the port number (1=serial sensor, 2=host, 3=USB), e.g.

```
CLOSEDIRECTPPP 3
```

will close the PPP session on the USB port.

A PPP session will also be automatically terminated if the USB cable is disconnected, or the modem connection drops out.

Troubleshooting

This section discusses a few possible reasons why a PPP connection may fail to connect. The error messages listed here are the common ones returned by Windows XP. Windows Vista is somewhat less helpful in that it simply indicates that "the connection failed", which could be due to any of the reasons below.

Error 663 – Modem already in use or not configured properly

This indicates that Windows could not open the specified COM port. Check that:

- the cables are properly connected
- you specified the correct COM port when creating the Windows modem device
- no other programs (e.g. *DeTransfer*) are currently using the specified COM port.

Error 691 – Access is denied

Check that the username and password specified in the **Connect** dialog exactly match that configured in the *DT80* profile.

Error 777 – Modem or remote computer is out of order

This indicates that the expected responses were not received from the *DT80*. Check that:

- for direct RS232 cable connections, the specified maximum baud rate matches that configured in the *DT80* profile.
- the port function setting in the *DT80* profile is set to COMMAND or PPP.
- if a modem is used, it appears to be dialling and connecting successfully. If not then check phone number and phone line.

Slow connection

When connecting, if there is a long pause (up to 60 seconds) during which **Registering your computer on the network** is displayed, this normally indicates that Windows is requesting a particular PPP option but that the *DT80* is rejecting it. One such option is "software compression"; ensure that this option is unchecked in the PPP Settings dialog (*Figure 75*).

Part L – Configuration

Configuring the DT80

Parameters

DT80 **parameters** are internal system settings. They are global in their effect, and allow a variety of options to be set. As a general rule, set the parameters that require changing before programming schedules and alarms.

Parameters are numbered from **P0** to **P62**, although not all numbers are used. Each parameter is an integer; the range of allowable values varies from parameter to parameter.

Reading Parameters

To read the current setting of a parameter, simply send the parameter's ID. For example, to read the value of P11:

```
P11
50
```

Setting Parameters

Parameters can be set at any time, and new settings generally take effect immediately. For example, send:

```
P11=60
```

to set parameter P11's value to 60.

Note Parameters are not channels. The statement **P11=60** is a **command**, and is carried out immediately, even if it appears within a schedule definition. You can use the **DO** command to set parameters when a schedule executes – see *Executing Commands in Schedules* (P54) for more information.

Parameter Lifetime

All parameter settings are cleared back to their default values when a soft or hard reset (**INIT** or **HRESET**) is performed, or if both external and battery power is lost.

To make a parameter setting "permanent", it should be set using the matching profile setting (see *Profile Settings* (P204)), e.g.

```
PROFILE PARAMETERS P11=60
```

When a parameter is set in the profile, it effectively becomes the new default value. You can still override it temporarily using the **P***nn*=*xx* command, but it will revert to the profile value if a soft or hard reset occurs.

To reset a parameter to its factory default value you can use

- **PROFILE PARAMETERS P11=** to reset a single parameter
- **PROFILE PARAMETERS=** to reset all parameters
- **FACTORYDEFAULTS** to reset all settings, including parameters, switches and profile settings

The *DT80* recognises the following parameters:

Parameter	Specifies	Units	Default Value	Range of Values	Comment
P0	Max analog input drift before re-calibration	µV	3	0 to 10000	Voltage measurements may "drift" as the ambient temperature changes. If the drift is greater than this amount the *DT80* will automatically re-calibrate itself to restore accuracy.
P3	Minimum sleep period	ms	1500	1 to 30000	The *DT80* will only go to sleep if the sleep duration can be for at least this period of time
P4	Sleep-to-wake latency	ms	800	1 to 30000	Time required by *DT80* to resume normal operation after leaving sleep mode
P8	Command processor diagnostic mode	mode	0	0 to 1	If this parameter is set to 1 then each and every command string will be displayed before being executed. This can be useful for verifying that alarm actions are being carried out, as these commands are not normally echoed.
P9	Logging of alarm state	mode	1	0 to 3	0 = do not log alarms 1 = log false to true transitions only 2 = log true to false transitions only 3 = log both transitions
P11	Mains frequency	Hz	50	1 to 10000	Sets analog measurement duration to 1/P11 seconds . Set P11 to the local mains frequency for best noise rejection.
P14	Comms ports password protection timeout	seconds	600	1 to 30000	When a password is defined, the *DT80* automatically signs off after this period of inactivity (see *Password Protection* (P161))
P15	Low-power operation	Mode	0	0 to 4	0 = Allow sleep if battery powered and Ethernet/USB not connected 1 = Allow sleep if Ethernet/USB not connected 2 = Do not allow sleep 3 = Allow sleep 4 = Allow sleep if battery powered See *Controlling Sleep* (P232)
P16	LED test mode	bitmask	0	0 to 32	0 = normal operation 32 = LCD backlight and all LEDs off 1-31: set specific LED pattern, as follows: bit 0 set = turn on **Power** LED bit 1 set = turn on **Attn** LED bit 2 set = turn on **Disk** LED bit 3 set = turn on **Sample** LED bit 4 set = turn on backlight
P17	Delay to low-power mode	seconds	30	1 to 30000	Sets how long the *DT80* waits before entering low-power sleep mode after the last communication or key press
P20	LCD backlight control	mode	2	0 to 3	0 = backlight off always 1 = backlight on always 2 = backlight on for P17 seconds after last user activity e.g. key press 3 = if externally powered: backlight on always; if battery powered: as for P20=2
P21	Analog subsystem power	mode	0	0 to 1	0 = analog subsystem powered during analog measurement only 1 = analog subsystem always powered
P22	Data delimiter character	ASCII	32 (space)	1 to 255	In free format mode with units disabled (**/h/u**), this character is inserted between the data value and the next data value
P24	Scan delimiter character	ASCII	13 (CR)	1 to 255	In free format mode with units disabled (**/h/u**), this character is inserted at the end of each schedule's data. Note that CR characters are always followed by LF.
P26	Flow control timeout	seconds	60	0 to 30000	If the *DT80* has been prevented from returning data for this amount of time (e.g. due to XOFF received or CTS not active) then it will assume that the host computer is no longer connected and will discard subsequent output text. Set to 0 to disable this timeout
P27	3HSC input mode	mode	0	0 to 3	Clock source for 3HSC counter 0 = **3C** terminal 1 = internal 32768Hz signal, count while **3C** terminal is low 2 = **3C** terminal, count while **4C** terminal is low 3 = internal 1024Hz signal
P28	12V power output mode	mode	0	0 to 3	0 = Auto CEM power. If schedule contains any CEM20 channels then 12V is turned on prior to any analog measurement, then turned off again at the end of the schedule if no other schedules are due. 1 = 12V on all the time

Parameter	Specifies	Units	Default Value	Range of Values	Comment
					2 = 12V on all the time including while asleep 3 = manual control of 12V output . CEM20s if used are assumed to be externally powered.
P31	Date format	mode	1	0 to 3	0 = days since 1-Jan-1989 1 = European (DD/MM/YYYY) 2 = North American (MM/DD/YYYY) 3 = ISO (YYYY/MM/DD)
P32	Number of significant digits	digits	8	1 to 9	Sets the number of significant digits shown in returned data or unloaded logged data
P33	Minimum field width	characters	0	0 to 80	If non-zero, all data values returned in free format mode (/h) will be padded with leading spaces so that the total field width is at least P33 characters.
P36	Temperature units	mode	0	0 to 3	Units for all temperature measurements: 0 = ºC Celsius 1 = ºF Fahrenheit 2 = K Kelvin 3 = ºR Rankine
P38	Decimal point character	ASCII	46 (.)	1 to 255	In CSV and free format mode (/h) data, this character is used as the decimal point character. CSV data separator automatically changed to ";" if this is set to comma (44).
P39	Time format	mode	0	0 to 3	0 = HH:MM:SS.TTT 1 = decimal seconds since midnight 2 = decimal minutes since midnight 3 = decimal hours since midnight
P40	Time separator character	ASCII	58 (:)	1 to 255	This character is used to separate HH, MM and SS fields in time values.
P41	Time sub-second digits	digits	3	0 to 6	Sets number of decimal places in time values
P50	Time instant format	mode	0	0 to 5	Specifies the format to use when returning an absolute date/time value: 0 = P39P22P31 (time, delimiter, date) 1 = P31P22P39 (date, delimiter, time) 2 = decimal seconds since 1-Jan-1989 3 = decimal minutes since 1-Jan-1989 4 = decimal hours since 1-Jan-1989 5 = decimal days since 1-Jan-1989
P51	Time interval format	mode	6	0 to 5	Specifies the format to use when returning a relative time value: 0 = P39P22d.d (time, delimiter, days) 1 = d.dP22P39 (days, delimiter, time) 2 = decimal seconds 3 = decimal minutes 4 = decimal hours 5 = decimal days 6 = P39 format (hours may be > 24)
P53	Default serial sensor timeout	seconds	10	0 to 30000	Max time that the *DT80* will wait for a serial sensor input or output action to complete. May be overridden by channel factor If P53=0 then characters satisfying the input action must already have been received at the time that the input action is processed.
P55	Enable schedule wakeup	bitmask	16383	0 to 16383	bit 0 = not used bit 1 set = wake from sleep if schedule X is due bit 2 set = wake from sleep if schedule A is due bit 3 set = wake from sleep if schedule B is due … bit 12 set = wake from sleep if schedule K is due bit 13 set = wake from sleep if schedule S is due By default *DT80* will wake if any schedule is due.
P56	Diagnostic output	bitmask	0	0 to 163832	Enable diagnostic output bit 0 set (e.g. P56=1) – SERIAL channel bit 1 set (e.g. P56=2) – SDI12 bit 2 set (e.g. P56=4) – Modbus bit 3 set (e.g. P56=8) – FTP bit 4 set (e.g. P56=16) – Modem
P62	Retain multiplexer settings after measurement	mode	0	0 to 1	0 = all terminals are disconnected from the *DT80* measurement and excitation circuits at the end of each scan 1 = connections are left set according to the last measurement in the schedule. This can be useful for verifying the *DT80*'s excitation output, or for rapid measurements of a single channel.

Table 5: DT80 Parameters

Switches

DT80 **switches** provide a further set of boolean parameters. Each switch is identified by a letter, and can either be **on** (uppercase) or **off** (lowercase).

Reading Switches

To read the current settings of all switches, use the **STATUS9** command *(P213)*, e.g.:

```
STATUS9
/C/d/E/f/h/i/K/l/M/N/R/S/t/U/w/x/Z
```

Switches that are ON are displayed in uppercase.

Setting Switches

Switches can be set at any time, and new settings generally take effect immediately. For example, send:

```
/T /e/m
```

to set switch T **on**, and set switches E and M **off**.

Note Switches are not channels. The statement **/T** is a **command**, and is carried out immediately, even if it appears within a schedule definition. You can use the **DO** command to set switches when a schedule executes – see *Executing Commands in Schedules* *(P54)* for more information.

Switch Lifetime

Switches work in the same way as parameters. All switch settings are cleared back to their default values when a soft or hard reset (**INIT** or **HRESET**) is performed, or if both external and battery power is lost.

As with parameters, to make a switch setting "permanent", it should be set using the matching profile setting (see *Profile Settings* *(P204)*), e.g.

```
PROFILE SWITCHES T=ON
```

The *DT80* recognises the following switches:

Switch	Function	Default	Comment
/C	Include Channel name	/C	Returns channel name before each data value (**/h** mode only)
/D	Include Date	/d	Returns current date before each scan's data. (**/h** mode only, see also **/N**)
/E	Enable command Echo	/E	Enables echo of commands to host computer (if not unloading data and not in fixed-format mode).
/F	Lock (Fix) schedules	/f	Prevents a *DT80*'s scan schedules (trigger or channel list) being modified. Note that a reset still erases the schedules.
/H	Fixed-format (Host) mode	/h	Returns data in fixed-format mode *(P25)*.
/I	Include Schedule ID	/i	Returns schedule ID before returning the schedule's data (**/h** mode only, see also **/N**)
/K	Enable automatic re-calibration	/K	Before each scan the *DT80* checks for drift due to changes in ambient temperature and re-calibrates if required.
/L	Include serial number	/l	Returns logger serial number before each scan's data (**/h** mode only, see also **/N**)
/M	Enable Messages	/M	Enables error and warning messages to be returned to host
/N	Include verbose ID	/N	Returns "**datataker 80** " before serial number (**/h/L** mode only) Returns "**Schedule** " before schedule ID (**/h/I** mode only) Returns "**Date** " before scan date (**/h/D** mode only) Returns "**Time** " before schedule ID (**/h/T** mode only)
/R	Enable data Return	/R	Returns real-time data to the host computer.
/S	Synchronize to midnight	/S	Synchronizes all schedules' time intervals to midnight — for example, **RA1H** scans on the hour. See *Time Triggers — Synchronizing to Midnight* *(P53)*.
/T	Include Time	/t	Returns current time before each scan's data. (**/h** mode only, see also **/N**)
/U	Include Units	/U	Appends measurement units to returned data (**/h** mode only) Separates data items by CRLF rather than P22 character (**/h** mode only) Makes error messages verbose
/W	Return Working channels	/w	Allows working channels (see **W** channel option *(P43)*) to be returned (for diagnostic purposes) but not logged.
/X	Progressive maxima and minima	/x	Displays the progressive maximum and minimum values for statistical channels on the built-in display only.
/Z	Enable alarm messages	/Z	Enables alarms to issue action text to host computer or printer.
//	Default switches	–	Sets all switches to their default state

Table 6: DT80 Switches

Profile Settings

The *DT80* **profile** is a group of named settings which control aspects of the logger's operation. Unlike parameters and switches, profile settings are "permanent", in that they are not cleared by a soft or hard reset (**INIT** and **HRESET** commands respectively, see *Resetting the DT80* *(P210)*)

Structure

The *DT80*'s profile settings are divided into a number of **sections**, each of which deals with a particular area, e.g. host port, modem, Modbus server, etc. Each section is identified by name, e.g. "**HOST_PORT**".

Each section then contains a number of **keys** (settings). Each key has a name (e.g. "**BPS**") and a value (e.g. "**57600**"). Depending on the key, the value may be a numeric, boolean (yes/no) or string value.

The value of any of the defined keys can be viewed of changed using the **PROFILE** command.

The PROFILE Command

The **PROFILE** command syntax is as follows:

Command	Description
PROFILE	return current settings for all profile keys
PROFILE *section*	return current settings for all profile keys in *section*
PROFILE *section key*	return current value of specified profile key
PROFILE *section key***=**	set specified profile key to default value
PROFILE *section***=**	set all keys in section to default value
PROFILE *section key***=***keystring*	set specified profile key to *keystring*. Enclose in quotes, i.e. "*keystring*" if the string contains spaces or control characters

Displaying Profile Settings

The following command will display all profile values in the **HOST_PORT** section:

```
PROFILE HOST_PORT
[HOST_PORT]
  BPS = 57600
  DATA_BITS = 8
  STOP_BITS = 1
  PARITY = NONE
 *FLOW = HARDWARE
  FUNCTION = COMMAND
```

When profile values are returned, an asterisk (*) before a key name indicates that the key has been changed from its factory default value. In the above example, to return the **FLOW** key to its default setting you would use:

```
PROFILE HOST_PORT FLOW=
```

Setting Profile Keys

The following command will change the default host baud rate to 115200 bps:

```
PROFILE HOST_PORT BPS=115200
```

Profile setting changes generally take effect immediately. So in this case, if the active command port was the host RS232 port then all subsequent commands would need to be sent at 115200 bps.

The *DT80* supports the following profile keys:

Section Name	Key Name	Legal Values	Factory Default	Comment
PARAMETERS	Pn	*integer* limits vary with parameter	varies with parameter	Sets the specified parameter to the specified value, and makes it the "default" value, i.e. the value to which it will be set on soft or hard reset. See *Table 5: DT80 Parameters (P202)*.
SWITCHES	A, B, C,…Z	OFF, ON	varies with switch	Similarly for switches See Table 6: *DT80* Switches *(P203)*
HOST_PORT	BPS	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	57600	Serial parameters for Host RS-232 port See *Configuring the Host RS-232 Port (P170)*
	DATA_BITS	7, 8	8	
	STOP_BITS	1, 2	1	
	PARITY	NONE, EVEN, ODD	NONE	
	FLOW	HARDWARE, SOFTWARE, NONE	SOFTWARE	
	FUNCTION	COMMAND, PPP, SERIAL, MODBUS, MODBUS_MASTER, DISABLE	COMMAND	Host port function: command/PPP interface, PPP interface, serial channel or Modbus
SERSEN_PORT	BPS	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600	1200	Serial parameters for Serial Sensor port See *Configuring the Serial Sensor Port (P173)*
	DATA_BITS	7, 8	8	
	STOP_BITS	1, 2	1	
	PARITY	NONE, EVEN, ODD	NONE	
	FLOW	HARDWARE, SOFTWARE, NONE	NONE	
	MODE	RS232, RS422, RS485	RS232	
	FUNCTION	COMMAND, PPP, SERIAL, MODBUS, MODBUS_MASTER, DISABLE	SERIAL	Serial sensor port function: command/PPP interface, PPP interface, serial channel or Modbus
USB_PORT	FUNCTION	COMMAND, PPP, SERIAL, MODBUS, MODBUS_MASTER, DISABLE	COMMAND	USB port function: command/PPP interface, PPP interface, serial channel or Modbus See *Configuring the USB Port (P162)*
HOST_MODEM	DIAL	*string*	ATD	Issued as prefix to number specified in the SETDIALOUTNUMBER command
	INIT	*string*	AT	String to send to initialise host port modem
	EXT_POWER_SWITCH	NONE, 1RELAY, *n*DSO, PWR12V	NONE	Output channel used to control modem power
	MAX_CD_IDLE	*integer* (seconds)	43200 (12 hours)	The number of seconds to wait while the **DCD** signal is inactive before re-initialising the modem (0=disable).
	SEND_BANNER_ON_CONNECT	YES, NO	NO	Send banner string such as dataTaker 80 Version 5.08 whenever the **DCD** signal changes goes active.
	COMMAND_PROCESSING_TIME	*integer* (seconds)	1	Delay between sending modem commands
ETHERNET	ENABLE	YES, NO	YES	Enable Ethernet port
	IP_ADDRESS	*n.n.n.n* or AUTO	AUTO	IP address to assign to the *DT80*'s Ethernet port AUTO = use DHCP to automatically set IP address, subnet mask, gateway and DNS servers.
	SUBNET_MASK	*n.n.n.n*	255.255.255.0	Subnet mask for the network segment connected to the *DT80*'s Ethernet port.
	GATEWAY	*n.n.n.n*	0.0.0.0	IP address of the computer that acts as a gateway to other networks. Set to 0.0.0.0 if there is no gateway
PPP	SERSEN_IP_ADDRESS	*n.n.n.n*	1.0.0.1	*DT80* IP address when using PPP connection to serial sensor port.
	HOST_IP_ADDRESS	*n.n.n.n*	1.0.0.2	*DT80* IP address when using PPP connection to host port.
	USB_IP_ADDRESS	*n.n.n.n*	1.0.0.3	*DT80* IP address when using PPP connection to USB port.

Section Name	Key Name	Legal Values	Factory Default	Comment
	SERSEN_REMOTE_IP_ADDRESS	*n.n.n.n*	1.0.1.1	IP address to assign to the host computer when using PPP connection to serial sensor port.
	HOST_REMOTE_IP_ADDRESS	*n.n.n.n*	1.0.1.2	IP address to assign to the host computer when using PPP connection to host port.
	USB_REMOTE_IP_ADDRESS	*n.n.n.n*	1.0.1.3	IP address to assign to the host computer when using PPP connection to USB port.
	USER	*string*	ANONYMOUS	User name and password that a remote PPP client must supply in order to connect to the *DT80* via PPP (not required for USB port)
	PASSWORD	*string*	PASSWORD	
FTP_SERVER	SUPPORTED	YES, NO	YES	Enable *DT80* FTP server
	USER	*string*	DATATAKER	Username and password that an FTP client must supply in order to be granted read/write access.
	PASSWORD	*string*	DATATAKER	
	ALLOW_ANONYMOUS	YES, NO	YES	If YES, read-only FTP access is permitted for anonymous users If NO, all FTP users must login using the configured username and password.
NETWORK	DNS_SERVER_1	*n.n.n.n*	0.0.0.0	IP address of primary DNS server. Must be set if host names (as opposed to IP addresses) are used for FTP transfers
	DNS_SERVER_2	*n.n.n.n*	0.0.0.0	IP address of secondary DNS server, to be used if primary server is unavailable.
COMMAND_SERVER	PORT	0-65535	7700	TCP port number used by command interface (0=disable)
HTTP_SERVER	DOC_ROOT	*string*	B:\WWW\	Base directory for web pages
	PORT	0-65535	80	TCP port number used by web server (0=disable)
MODBUS_SERVER	TCPIP_PORT	0-65535	502	TCP port number used by Modbus server (0=disable)
	SERSEN_ADDRESS	0-247	0	The DT80's slave address when using Modbus on the serial sensor port (0=disable)
	HOST_ADDRESS	0-247	0	The DT80's slave address when using Modbus on the host port. (0=disable)
	USB_ADDRESS	0-247	0	The DT80's slave address when using Modbus on the USB port. (0=disable)
NTP	BACKGROUND_ENABLE	YES, NO	NO	Periodically synchronise *DT80* system time to an NTP server
	SERVER	*string*	0.datataker.pool.ntp.org	NTP server address (numeric IP address or host name)
	BACKGROUND_PERIOD	*time* 30M-7D	3599S	Interval between NTP updates
	MAX_SLEW_CORRECTION	*time* 0-60S	1800T	Max allowable time adjustment using "gradual" adjustment method
	MAX_JUMP_CORRECTION	*time* 0-24H	24H	Max allowable time adjustment using "time jump" method
	MIN_CORRECTION	*time* 0-24H	0	Minimum time adjustment to apply
	SLEW_RATE	1-50	10	Percentage change to clock rate during gradual adjustment
	TIMEOUT	*time* 0-10S	200T	NTP request timeout
	BACKGROUND_WAKEUP_DELAY	*time* 0-10M	3S	Delay following wakeup before first NTP request
LOCALE	TIME_ZONE	*time* -24H-24H	0	Local time zone offset
STARTUP	RUN	CURRENT_JOB, NONE, *jobname*	CURRENT_JOB	Job to be automatically loaded following hard reset
	MAINTAIN_OUTPUTS	YES, NO	NO	Restore state of digital outputs 1..8DSO and 1RELAY following hard reset
DISPLAY	AUTOSCROLL_INTERVAL	*time* 0-24H	0	Auto scroll through channel screens on LCD at this rate (0=disable)
	AUTOSCROLL_DELAY	*time* 0-24H	30S	Suspend autoscroll for this time if key pressed
	AUTOACK_DELAY	*time* 0-24H	0	Auto-acknowledge pop-up messages on LCD after this time (0=disable)
FUNCTION	F*n*_LABEL	*string*	(empty)	Label for LCD function key #*n* (*n*=1-10)
	F*n*_COMMAND	*string*	(empty)	Command string for LCD function key #*n* (*n*=1-10)

Table 7: DT80 PROFILE Details

Values marked *time* in the table are specified in a similar way to schedule time intervals – that is, an integer followed by a unit letter (**D**, **H**, **M**, **S** or **T** for days, hours, minutes, seconds and milliseconds respectively).

Examples

To set the *DT80*'s IP address for the Ethernet port:

```
PROFILE ETHERNET IP_ADDRESS=192.168.1.225
```

To set the default date format to North American style:

```
PROFILE PARAMETERS P31=2
```

Note Special characters may be inserted into profile values using **^***x* or *****nnn* notation, as described in *ASCII-Decimal Tables* *(P316)*. This means that if the profile value requires an actual **** character then it must be entered twice, e.g.

```
PROFILE HTTP_SERVER DOC_ROOT=B:\\WWW\\FLASH\\
```

Remember also that if *DeTransfer* is used to send the above line then the backslashes must be doubled again, i.e.

```
PROFILE HTTP_SERVER DOC_ROOT=B:\\\\WWW\\\\FLASH\\\\
```

Setting the System Time

The *DT80*'s real-time clock/calendar is based on a 24-hour clock that has a resolution of approximately 0.1ms. This is used to timestamp all logged data.

Time and date are maintained when the logger is switched off or reset. If the logger is switched off and the internal Memory-Backup battery (see *Internal Memory-Backup Battery* *(P225)*) is removed or discharged, then the date and time will be reset to 1989/01/01 00:00:00

D and T Channel Types

The *DT80*'s time and date can be set using the **T** and **D** internal channel types (*Time* *(P33)*), e.g.:

```
T=13:05
Time 13:05:00.000

D=1/4/2006
Date 01/04/2006
```

The time and date must be specified in the current P39 and P31 formats.

The time can also be set to a CV value, where the CV value is the number of seconds since midnight. Similarly for the date, except the value is now the number of seconds since the base date (1/1/1989).

For example, to set the system time forward one hour you could use:

```
T(=1CV) 1CV(W)=1CV+3600 T=1CV
Time 15:59:23.460
Time 16:59:23.461
```

Note that only a single CV can be placed after the "=". Expressions are not supported.

DT Command

Alternatively, the **DT** command can be used to set both date and time. In this case the date/time is specified either in dataTaker ISO format or ISO8601 format and enclosed in square brackets, e.g.:

```
DT=[2006/04/01,13:05:00]
```
or
```
DT=[2006-04-01T13:05:00]
```

Time Zone

Depending on the application, you may choose to set the *DT80*'s time to either:

- local time. In this case you may need to alter the time periodically to adjust for daylight saving time, if applicable.
- local standard time. The logger is still set to the local time zone, but no correction is made for daylight saving time.
- UTC (GMT) time. This may be appropriate if there are a number of *DT80*s (connected to the host computer via a wide area TCP/IP network, for example) which are in different time zones.

The *DT80* and the *dataTaker* host software currently do not provide any specific support for data collected in disparate time zones – it is therefore up to the user to manage this.

Note If the *DT80* system time is synchronised to an NTP server (see below), and the *DT80* time is set to local or local standard time, then the **TIME_ZONE** profile setting must be set correctly. If NTP is not used then this profile setting is not used.

Automatic Time Adjustment (NTP)

Network Time Protocol (NTP) allows devices on a TCP/IP network to synchronise their clock to an NTP server, which will in turn be linked to a very accurate time reference.

If your *DT80* has Internet access, or if you have access to an NTP server on your local network, then you can enable the *DT80*'s automatic time adjustment feature. The *DT80* will then periodically (by default, hourly) contact the NTP server and if necessary adjust its clock/calendar to match.

For small time adjustments (by default, up to 1.8 seconds) the *DT80* will gradually adjust its time by speeding up or slowing

down its clock for a period of time. This avoids any sudden changes in time, and the time will never go backwards (which could have caused complications when you came to interpret the logged data). This process is also referred to as "slewing" the time.

For example, if the NTP server indicates that the *DT80* time is 1.2 seconds fast then the *DT80* clock will be slowed down by 10% (by default). After 13.2 seconds (12.0s as measured by the *DT80* clock) the required time adjustment of -1.2s will have been made and the clock rate will be set back to normal.

If a larger time adjustment is required, the "gradual" method is impractical and the *DT80* will do a "jump" adjustment, where the time will change instantaneously (forward or backward). A message is logged to the event log (see *Event Logs* (P213)) each time a time jump occurs (including manual time changes).

Using NTP

In order to use NTP, you first need to ensure that you have an accessible NTP server.

If the *DT80* has access to the Internet then you can use the public NTP server at **0.datataker.pool.ntp.org**.

Alternatively, a local NTP server may be available on the local area network to which the *DT80* is connected. If this is the case then you will need to find out the IP address or host name of the NTP server. Note that using a local server will normally result in better time accuracy, because it avoids the variable delays that may occur when making a request over the Internet.

Once you have determined the address of the NTP server that you wish to use, you can enable NTP updates by setting the following profiles:

```
PROFILE LOCALE TIME_ZONE=offset
PROFILE NTP SERVER=host address
PROFILE NTP BACKGROUND_ENABLE=YES
```

The timezone setting (*offset*) is the time difference between UTC (GMT) time and the logger's local time. For example, for Pacific Standard Time (UTC-8:00), use

```
PROFILE LOCALE TIME_ZONE=-8H
```

while for Australian Central Standard Time (UTC+9:30), use

```
PROFILE LOCALE TIME_ZONE=570M
```

(9.5 hours = 570 minutes)

The NTP server address (*host address*) may be specified as a numeric IP address (e.g. `10.2.30.212`) or as a host name (e.g. `ntp3.petacorp.com`). Using a host name requires that the *DT80* have access to a working DNS (domain name system) server.

NTP Options

The above three profile settings are the minimum that need to be set in order to enable NTP updates. There are, however, a number of settings that may be adjusted to suit particular applications.

Time Request Interval

By default, the *DT80* will perform a time request every 3599 seconds. Selecting a value of "not quite one hour" helps ensure that the *DT80*'s requests do not ever end up always occurring "on the hour". NTP servers tend to be busiest at this time and this can cause reduced time accuracy for requests made at these times.

The request interval can be changed to any value from 30 minutes to 7 days, using the following profile:

```
PROFILE NTP BACKGROUND_PERIOD=time
```

where *time* is a time value such as `50M` (50 minutes) or `97H` (97 hours)

Correction Limits

When the *DT80* obtains a time value from the NTP server, it will do one of the following, based on the magnitude of the required time adjustment:

- do nothing (the *DT80* time is already "close enough")
- begin a gradual time adjustment (speed up or slow down the *DT80* clock rate until it reaches the correct time)
- immediately set the *DT80* time to the NTP server value
- do nothing (the time difference is very great – possibly the NTP server is faulty)

The following profiles set the thresholds between these behaviours:

- `PROFILE NTP MIN_CORRECTION=`*time* specifies the smallest time adjustment that will be applied. By default this is 0, so all NTP updates will be applied, even if the time error is only very small.
- `PROFILE NTP MAX_SLEW_CORRECTION=`*time* specifies the largest adjustment that will be performed using the "gradual" adjustment method. By default this is 1.8 seconds (`1800T`). Setting this larger will reduce the chance of time jumps in logged data, at the expense of possibly allowing larger time deviations from the true time.
- `PROFILE NTP MAX_JUMP_CORRECTION=`*time* specifies the largest adjustment that will be performed using the "jump" adjustment method. If the time difference is greater than this then the *DT80* will reject it and do nothing. By default this setting is 24 hours (`24H`). This value allows a logger that has changed time zone to receive its initial time update from NTP rather than having to be set manually. However you may wish to reduce this value in order to prevent the *DT80* clock being changed when the server time difference is unexpectedly large – possibly due to a faulty server. Set to 0 to disable "jump" corrections altogether.

If all power to the *DT80* is lost, including the internal lithium battery, then the *DT80*'s clock will be reset to 1-Jan-1989. As a

special case, therefore, if the *DT80* finds that its date is set to a value earlier than 2000 then it will apply any NTP update, even though the "max jump correction" limit is exceeded.

Gradual Adjustment Rate

By default, during a gradual time adjustment the *DT80* clock will run 10% faster or slower. This rate can be adjusted between 1% and 50% using the following profile:

PROFILE NTP SLEW_RATE=*percent*

Lower rates will give a more gradual time adjustment, which may be preferable if your data is being logged at a fast rate, at the expense of the adjustment process taking longer.

Communications Timing

When the *DT80* sends a time request, it expects a timely reply. A late reply (e.g. due to network congestion) may be worse than no reply at all, given that the purpose of the message is to accurately set the *DT80* time. Consequently the default communications timeout for NTP is set to be quite short (200ms, or **200T**). If, however, you have a slow or unreliable network connection then you may need to increase this, using the following profile:

PROFILE NTP TIMEOUT=*time*

Sleep Wakeup Timing

Each time the *DT80* wakes from sleep, it will attempt to perform an NTP time update. However, it can take a little time for the network to become operational following wake – for example a DHCP query may need to be done. By default therefore, the *DT80* will, after waking up, wait 3 seconds before attempting an NTP request. This may be adjusted up or down using the following profile:

PROFILE NTP BACKGROUND_WAKEUP_DELAY=*time*

Manually Triggered NTP Requests

When background NTP requests are enabled in the profile, a request will be performed:

- at the configured time intervals
- following hard reset
- following wake from sleep
- following any change to any of the NTP profile settings

An NTP request can also be triggered manually, regardless of whether or not background NTP updates are enabled. This is done using the **NTP** command. This command may then be included in a schedule, inside an **ALARM** or **DO** statement, which allows more control over the timing of NTP requests.

The **NTP** command will perform an immediate NTP request, using the settings defined in the profile (the **BACKGROUND_ENABLE**, **BACKGROUND_PERIOD** and **BACKGROUND_WAKEUP_DELAY** settings will be ignored)

Checking NTP Status

System variable 26SV reports the status of the last NTP request, as follows

26SV	Meaning
0	No NTP requests have been performed
1	Gradual time adjustment in progress
2	Time adjustment completed successfully
-1	Could not resolve NTP server name
-2	NTP request failed: could not connect to server, or no response within timeout time
-3	Required time adjustment was not performed because it exceeded the **MAX_SLEW_CORRECTION** and **MAX_JUMP_CORRECTION** settings.
-4	NTP request failed due to an internal *DT80* error
-5	Daily limit of 50 requests to **0.datataker.pool.ntp.org** was exceeded

System variable 27SV returns the discrepancy between the *DT80*'s time and the NTP server, as at the last successful NTP request. If the NTP request resulted in the *DT80* clock being adjusted, 27SV holds the discrepancy before the correction was applied. For example, a value of -150 indicates that the logger time was 150ms ahead of the NTP server time. 27SV=0 if no NTP requests have been made.

Any request that results in a "time jump" adjustment will also be logged to the event log.

Resetting the DT80

The *DT80* can be **reset** in the following ways:

- **soft reset** – clears current job and resets parameters and switches
- **hard reset** – restarts *DT80* firmware
- **safe mode reset** (a.k.a. **triple push reset**) – restarts *DT80* firmware and runs using factory default settings.

Soft Reset

The **INIT** command performs a **soft reset**, which has the following effects:

- The message `Initializing...` is returned.
- The current job is cleared, i.e. all schedule and channel definitions are cleared.
- All span/polynomial definitions are cleared.
- All CVs are reset to 0.0.
- All parameters and switches are reset to their power-on default values, as specified in the associated profile settings.
- All digital outputs are reset to their default state.
- All counter channels are reset to 0.
- All Modbus definitions set using the **SETMODBUS** command are cleared.
- All serial port settings set using **PH=** and **PS=** revert to the settings specified in the profile.
- The modem dialout number set by **SETDIALOUTNUMBER** is cleared.
- A self-calibration is performed.

A soft reset is analogous to closing and restarting an application on a PC.

Hard Reset

A **hard reset** causes all *DT80* hardware to be physically reset, and the *DT80* firmware will be restarted. A hard reset may be caused by:

- the **HRESET** command
- pressing the manual reset button (by inserting a straightened paper clip into the small hole between the Ethernet and USB connectors)
- applying power following a complete loss of power (e.g. external power disconnected and the battery link is not in place, or the main battery is completely flat)
- applying power after the *DT80* entered forced sleep mode due to battery voltage dropping below power fail threshold.
- the *DT80* detecting a critical error such as a serious hardware fault, or an internal inconsistency in the firmware. In these situations a hard reset is forced in order to try to return the *DT80* to a stable operational state.

A hard reset is analogous to rebooting a PC.

A hard reset has the following effects:

- All TCP/IP (Ethernet or PPP) connections are terminated.
- USB connection is terminated if power was lost.
- All communications and other settings are read from the profile and applied.
- All LEDs flash rapidly four times.
- If the reset was due to a power failure, manual reset button or critical error, then a message is displayed on the LCD (e.g. `DT80 restarted` / `Power loss`) and the **Attn** LED starts flashing.
- A sign-on message e.g. `dataTaker 80 Version 8.00` is returned. (This can be disabled if required by switching off the messages flag in the startup profile, i.e. **PROFILE SWITCHES M=OFF**)
- A **soft reset** is performed, as described in the previous section.
- If the **STARTUP** / **MAINTAIN_OUTPUTS** profile is set to **YES** then all digital outputs are restored to the state they had prior to the reset.
- The job that was running prior to the reset is re-loaded, and becomes the current job. Alternatively, a particular job or no job at all may be loaded by setting the **STARTUP** / **RUN** profile.

Note A hard reset may take a few seconds to perform. You should refrain from sending further commands to the *DT80*

during this time.

Safe Mode

If there is an error in the *DT80*'s profile settings or the job that is automatically loaded following hard reset then you may find that you are unable to communicate with the logger. For example – the startup profile specifies the wrong RS232 parameters (and you're not sure what they are), or the job specifies an immediate **1SERIAL** channel with a very long timeout (and the serial channel is not connected to anything).

Safe Mode provides a mechanism to regain control and fix the problem. To select safe mode you need to perform a "triple-push" reset:

1. Press the manual reset button
2. Wait approximately 3 seconds, then press the reset button again.
3. Wait approximately 3 seconds, then press the reset button a third time.
4. Verify that **DT80 restarted** / **Safe mode** is displayed on the LCD.

This will have the same effect as a **hard reset**, except that:

- all profile settings are ignored – factory default settings are used (for example, the host port parameters will be set to **57600,8,N,1,SWFC**)
- no job is loaded

Note that the profile settings are not cleared – they are simply ignored for this session only. If you now do a normal hard reset they will once again be loaded.

Factory Settings

To restore the *DT80* to factory default settings, send the **FACTORYDEFAULTS** command, which will reset all profile settings to their factory defaults, then perform a hard reset.

Note that this command does not delete any files from the internal file system. The **DELALLJOBS** command may be used to remove all jobs and all logged data.

Diagnostic Commands

TEST Command

The **TEST** command causes the *DT80* to perform a self-calibration, then run a series of self tests. Test results that are out of range are flagged with a FAIL message.

This command can also be issued via the *DT80* web interface (Series 2 only).

A typical test report is shown below.

```
   TEST

   TEST report generated at 2008/02/13,16:05:09
 0 dataTaker 80 Version 7.02.0002 Flash 2007/12/21 17:09:56

29 Product:          DT80-2
 1 Serial Number:    080043

 2 VEXT                 11.0   V
 3 VBAT (6V)            6.74   V   PASS
 4 IBAT                  +13  mA   PASS
 5 VSYS                 6.71   V   PASS
 6 VLITH (3.6V)         3.68   V   PASS
 7 VDD (3.3V)           3.25   V   PASS
 8 VANA (3.8V)          3.65   V   PASS
 9 VRELAY (4.5V)        4.20   V   PASS

10 VREF (2.5V)       2509.72  mV   PASS
11 Ics I             0.21341  mA   PASS
12 Ics II             2.5755  mA   PASS
13 Vos diff             -0.2  uV   PASS
14 Vos 3W I            345.7  uV   PASS
24 Vos 3W II           -58.7  uV   PASS
15 Vos shunt            -1.2  uV   PASS
16 Vos +                 2.4  uV   PASS
17 Vos -                 2.9  uV   PASS
18 Vos *               -24.3  uV   PASS
19 Vos #                57.6  uV   PASS
25 Vos diff atten       -0.3  uV   PASS
26 Vos + atten          64.4  uV   PASS
27 Vos - atten          67.7  uV   PASS
28 Vos * atten          37.2  uV   PASS
20 Term. factor      1.00470       PASS
21 Shunt (100R)       99.681 Ohm   PASS
22 CMRR                137.3  dB   PASS

23 Overall health                 PASS
```

You can also request just one line of the report using **TEST***n*, where *n* is the line number (0-29, as indicated above). For example, the following will return the firmware version number:

```
TEST0
dataTaker 80 Version 7.02.0002 Flash 2007/12/21 17:09:56
```

Some other useful test report parameters are described below:

- Product – this indicates the product type and series, for example DT80-2 indicates a DT80 Series 2.
- Serial number – this should match the number on the label affixed to the outside of the unit.
- VEXT – the voltage at the external power input.
- VBAT – internal battery terminal voltage.
- IBAT – internal battery current: positive when battery is charging, negative when discharging.
- VLITH – internal memory backup battery terminal voltage.

The other parameters listed in the test report are generally only useful to Datataker service personnel. A description of these entries is beyond the scope of this manual.

Note that if the main or Lithium battery are absent then there will be FAIL lines in the output from the normal TEST command

but this will not affect the overall pass/fail result.

Power on Self Test

The TEST command is also run automatically, following a hard reset. If this test fails then

```
Self test failed
```

is displayed on the LCD in conjunction with two flashing LEDs, and a message is output to comms port and event log. Press any key to clear the LCD message. You should then send a **TEST** command to see which particular test is failing.

If the power-on test passes there will be no indication (no report is generated).

Event Logs

To aid in troubleshooting, the DT80 automatically logs significant events into an event log, which is a text file **B:\EVENTS\EVENT.LOG**. These events include:

- any of the errors listed under *Error Messages* *(P324)*
- USB memory device inserted
- external power connected or disconnected
- system time changed
- low power forced sleep
- FTP errors
- logger reset
- safe mode (triple push) reset
- self test failure
- logger not characterised warning
- user defined messages, using the **LOG "***string***"** command

The event log may help pinpoint the cause of any unexpected readings or failures, and will be used by Datataker engineers if the *DT80* is returned for service.

In the event of an abnormal reset due to a firmware error, the *DT80* may store additional information in a companion file, the **error log** (**B:\EVENTS\ERROR.LOG**).

The contents of the event and error logs can be viewed using the **UEVTLOG** and **UERRLOG** commands.

They may also be viewed via the web interface.

The event and error logs can be cleared using the **CEVTLOG** and **CERRLOG** commands.

STATUS Command

The **STATUS** command returns a report showing the status of the *DT80*'s schedules, channels, alarms, memory and logging to the host computer. A typical report is shown below:

```
STATUS
dataTaker 80 Version 6.16.0002 Flash 2007/03/21 17:09:56
A B C,F Scan Schedules Active,Halted
4,0 Alarms/IFs Active,Halted
0 Polynomials/Spans Defined
A B C F,none Scan Schedules LOGON,LOGOFF
61650,1026 Internal kB free,used
0,0 External kB free,used
/C/d/E/f/h/I/K/l/M/N/r/S/t/U/w/x/Z
```

If the **/u** switch is set (don't display units) then the descriptive text on the end of each line is not returned.

As with the **TEST** command, lines in the status report can be returned individually, using **STATUS***n*.

Command	Description
STATUS1	returns model name and firmware version (same as **TEST0**)
STATUS2	lists active schedules, and halted schedules
STATUS3	returns the number of alarms in active schedules, and the number in halted schedules
STATUS4	returns the number of polynomial/spans defined, and displays the definition of each
STATUS5	lists schedules with logging enabled, and schedules with logging disabled
STATUS6	returns total free space (kbytes) on internal file system, and total used space
STATUS7	returns total free space (kbytes) on inserted USB memory device, and total used space
STATUS9	returns current settings for all switches
STATUS10	returns internal details about the current job

STATUS14	an extended version of **STATUS10**

The **STATUS14** command is somewhat special in that it can also be applied to a non-current job, i.e.:

```
STATUS14 "jobname"
```

CHARAC Command

During manufacture, each *DT80* is **characterised** – that is, various operational parameters are measured and then programmed into the unit's flash memory. This process is designed to cancel out any variations between units due to component tolerances and such like.

The **CHARAC** command lists the various characterisation parameters. These will vary slightly from unit to unit.

If any of these parameters have not been set correctly then a warning message such as

```
DT80 not characterised
```

will be displayed on the LCD. Contact Datataker support if you see this message.

SERVICEDATA Command

The **SERVICEDATA** command automatically issues a number of diagnostic commands which together provide a comprehensive "snapshot" of the current state of the *DT80*. If you contact Datataker support to resolve a problem with the logger you may be asked to run this command and then send the results to Datataker for analysis.

By default, this command will output its results to the current comms connection. Alternatively, it may be directed to a text file using: **SERVICEDATA** "*filename*". This file may then be retrieved from the logger using FTP or by using the **COPY** command to copy it to a USB memory device.

This command can also be issued via the *DT80* web interface (Series 2 only).

A **SERVICEDATA** report includes:

- **TEST** command output
- **CHARAC** command output
- **STATUS** command output
- current parameter settings
- current profile settings
- event log
- error log
- current job program listing
- **DIRJOB*** command output (storefile status for all jobs)
- **DIRTREE** command output
- internal file system integrity check
- comms settings and statistics
- firmware thread status
- memory status
- TCP/IP communications status

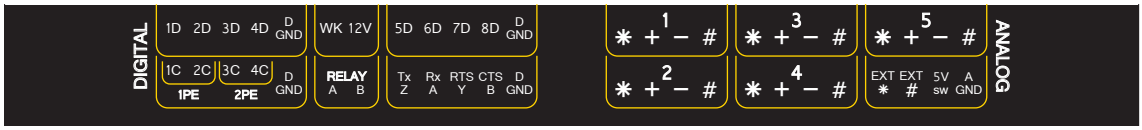
Part M – Hardware & Power

Inputs and Outputs

DT80 Wiring Panel

The front face of the *DT80* is the sensor interface. Removable screw terminal blocks make it easy to connect and disconnect sensor wiring.

The terminals are labelled as shown below. Note that the label is removable, so it can be replaced with application specific labelling if required.



DT80/80G Series 3

DT81 Series 2

DT82E Series 3

DT82I Series 3

DT85/85L Series 3

DT85G/85GL Series 3

Note: for DT80/81 Series 1 units, **DGND** replaces **12V**, **EXT*** replaces **5V SW**, **AGND** replaces **EXT#**
for DT80/82/85 Series 2 units, **EXT*** replaces **5V SW**, **EXT#** replaces **AGND**

Figure 79 Standard terminal labels for DT80, DT81, DT82 and DT85

The sensor interface comprises:

- **1D – 8D**: Digital Input/Output Channels *(P261)*
- **WK**: Wake Terminal *(P232)*
- **12V**: 12V power output (not DT80/81 Series 1) *(P224)*
- **DGND**: Digital Ground *(P297)*
- **1C – 4C**: High Speed Counter Inputs *(P268)*, shared with Phase Encoder Inputs (**1PE – 2PE**) *(P270)*
- **5C – 7C**: High Speed Counter Inputs, shared with Phase Encoder Input (**3PE**) (DT85/85L Series 3 only)
- **RELAY**: Relay Output *(P263)*
- **PWR OUT**: Unswitched external power output (DT85) *(P224)*
- **Tx/Z Rx/A RTS/Y CTS/B**: Serial Sensor Port *(P171)*
- **1 – 16** (*** + – #**): Analog Input Channels *(P233)*
- **5V SW**: Isolated switched 5V output (Series 3)
- **AGND**: Analog Ground *(P297)*
- **EXT***: External Excitation Input *(P20)*
- **EXT#**: Switched Analog Ground (not DT80/81 Series 1) *(P297)*

DT80 Front Panel

The top face of the *DT80* is the user interface – keypad, display, indicators and USB memory device slot. See *DT80 Front Panel* *(P108)*

DT80 Side Panel

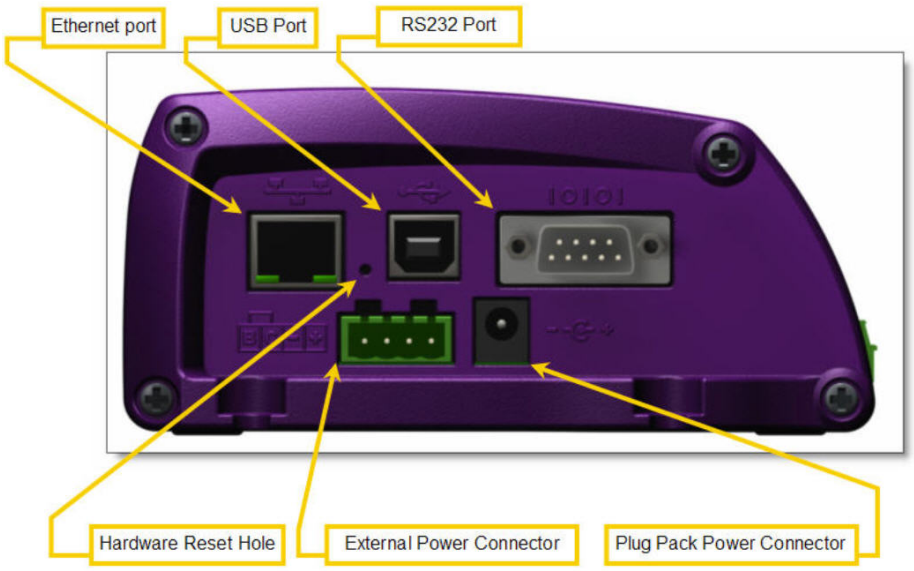


Figure 80 DT80 Side Panel

The *DT80*'s side panel provides communications and power interfaces:

- Ethernet Port *(P179)*
- USB Port (not present on DT82E/82I) *(P162)*
- RS232 Port *(P168)*
- Hardware Reset Hole *(P210)*
- External Power Connector *(P221)*
- Plug Pack Power Connector (2-pin connector on DT82E/80L/85L) *(P221)*

A threaded hole is also provided as an earthing point. This is internally connected to DGND.

For DT80G/85G GeoLoggers, there is also a headphone jack on the rear panel, normally covered by a rubber grommet. This is used for checking the response of vibrating wire strain gauges.*(P256)*

Inside the DT80

Accessing the main battery (not DT80G/DT82E)

1. Remove the power connector

2. Remove the screws from the other end of the logger

3. Remove this end of the logger

4. Pull the purple 'battery tail'

5. Disconnect the battery terminals

Figure 81: How to remove the main battery

Accessing the lithium memory backup battery

1. Remove the power connector

2. Remove all the terminal blocks

3. Terminal blocks removed

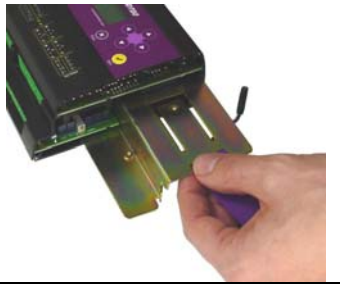
4. Remove the screws from the right hand end of the logger

5. Remove this end of the logger

6. Pull the purple 'battery tail'

7. Disconnect the battery terminals

8. Remove screws (2 for DT80/81, 3 for DT85) on bottom of logger, and then remove the battery cage.



9. Slowly remove the circuit board bundle. Be careful of the flexible cable running between the top circuit board and the keypad. It is not necessary to completely remove the circuit boards from the case.

10. Open the boards slightly so the lithium battery can be removed.

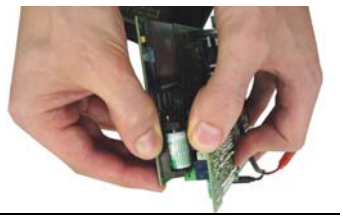


Figure 82: How to remove the lithium battery

Mounting the DT80 *and CEM20*

Dimensions

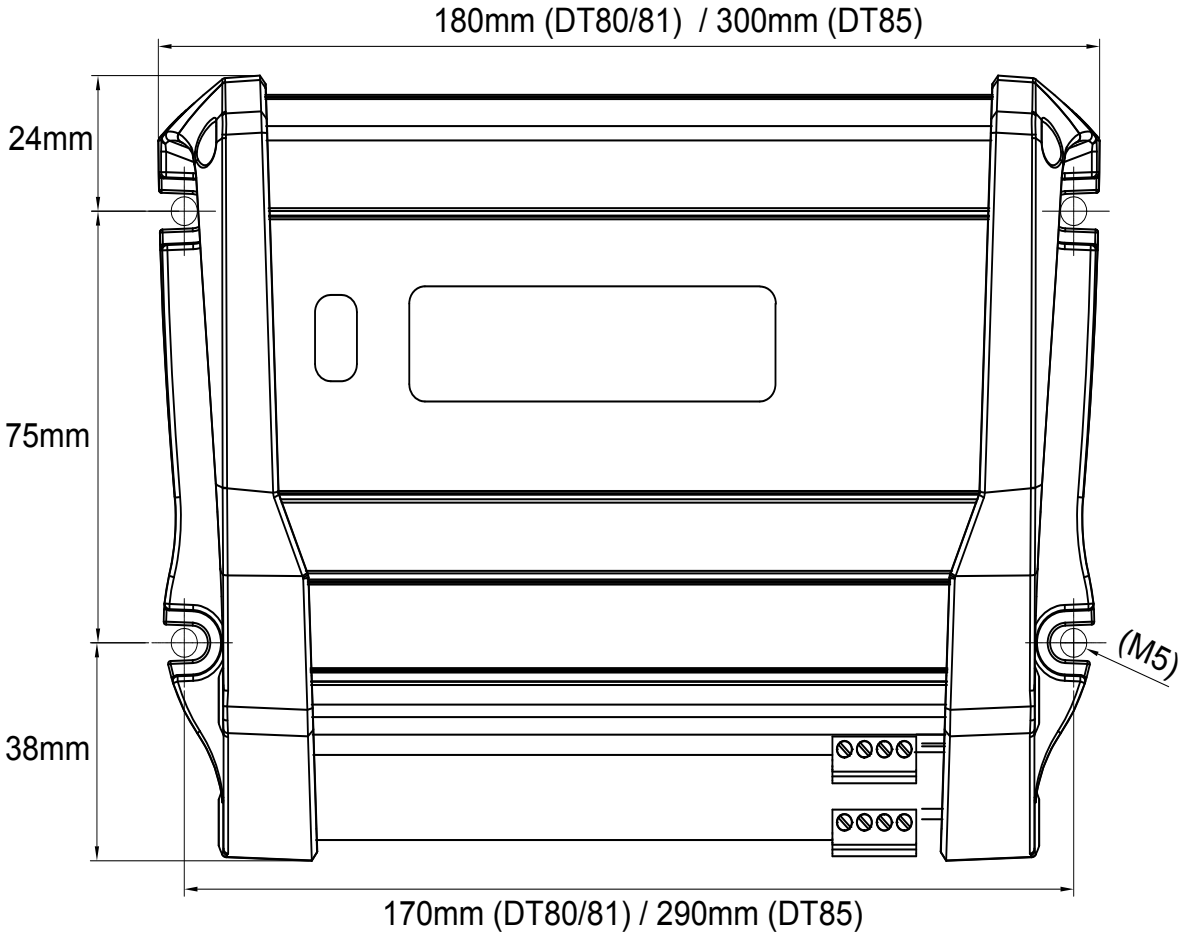


Figure 83: Mounting hole positions and overall dimensions

- DT80/81 overall dimensions (L x W x H): 180mm x 137mm x 65mm
- DT85 overall dimensions: 300mm x 137mm x 65mm
- CEM20 overall dimensions: 180mm x 100mm x 50mm. Note that CEM20 mounting hole centres are the same as for the DT80/81.
- Mounting screw size: M5
- Some clearance for communications/power cabling will be required on the left hand side of the unit, and at the front for sensor wiring.
- Logger should be oriented either in table top configuration (keypad/display facing up), or wall mounted (terminals facing down). Do not wall mount with terminals facing upwards.

Operating Environment

The *DT80* is an electronic instrument. Electronics and water in any form do not mix. Condensation can be a serious problem in the tropics, and in cooler areas where wide temperature variations are possible. Use a sealed case and include sachets of silica gel to avoid problems.

If the *DT80* gets wet, immediately disconnect and remove all power sources (including the main internal battery), and dry the *DT80* in a warm place. If the unit comes into contact with salt water, rinse it thoroughly in fresh water, then in distilled water, then dry it — salt must NOT be allowed to remain on the circuit boards.

The *DT80* operates over a wide temperature range (–45°C to +70°C), but its accuracy can be reduced at extremes. Try to minimize the *DT80*'s exposure to temperature extremes.

The capacity and service life of the lead acid battery in the logger will be significantly reduced if it is operated outside the range -15°C to +50°C. Furthermore, if the battery is subject to regular charge/discharge cycles then the recommended temperature range is +5°C to +35°C. When operating outside these ranges consideration must be given to an alternative power source for the logger.

The LCD display is typically only usable over a temperature range of 0°C to +50°C.

Powering the DT80

Power Subsystem

The following block diagrams give an overview of the *DT80's* internal power subsystem.

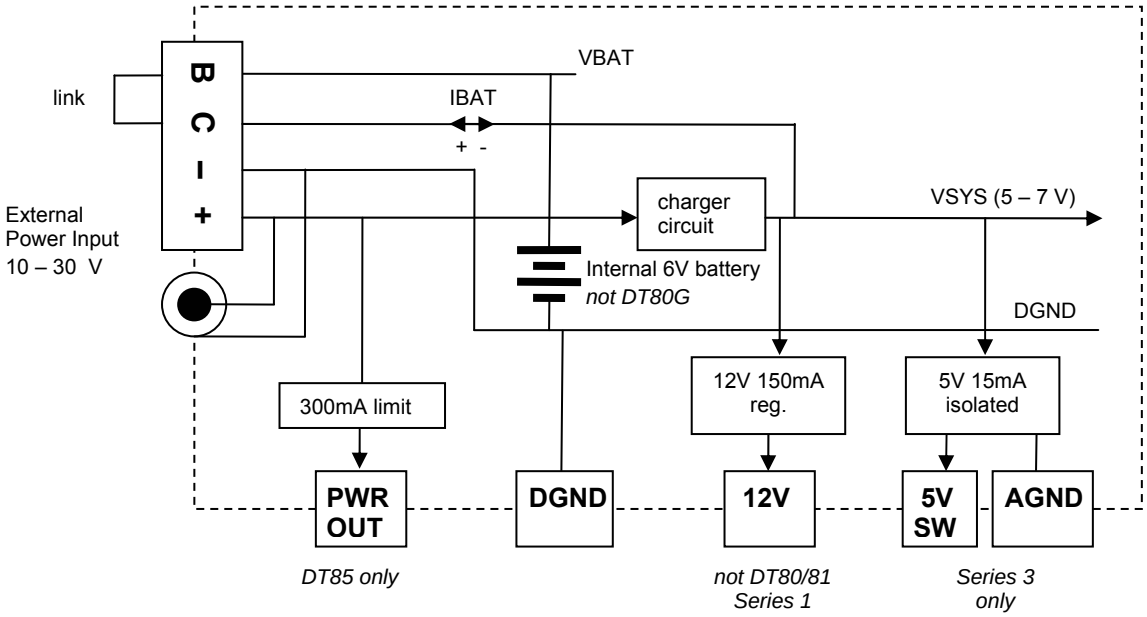


Figure 84: DT80/81/82I/85 internal power subsystem

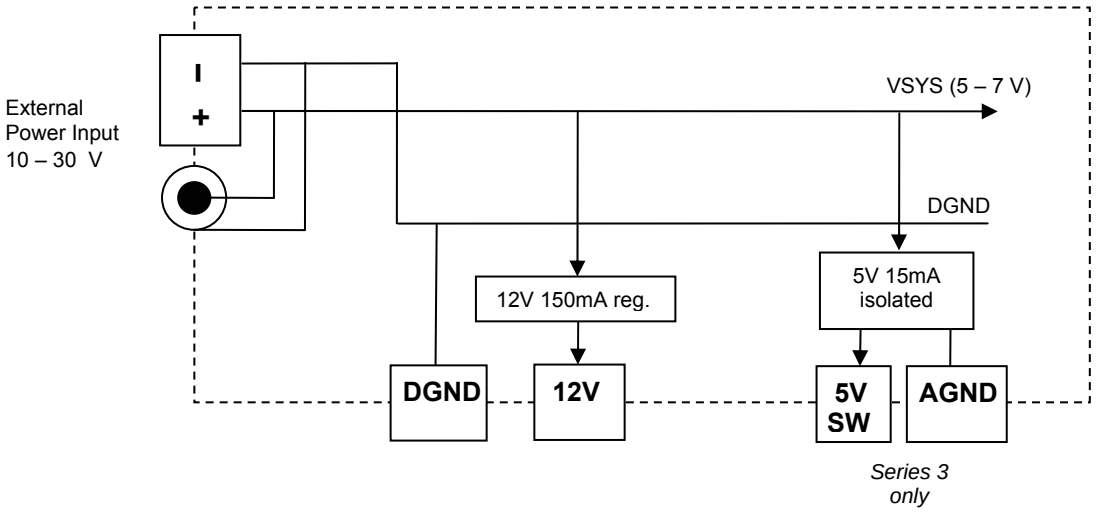


Figure 85: DT82E/80L/85L internal power subsystem

External Power

The *DT80* is normally powered by an external 10-30V DC supply. This might, for example, be:

- a mains supply (e.g. using the supplied plug pack)
- a 12V or 24V solar charged external battery
- a 12V or 24V vehicle supply.

This external power supply may be connected in one of two ways:

- the round plug pack power socket (inner pin is positive)

- the rightmost two terminals (**-** and **+**) of the adjacent 4-way removable screw terminal power connector. This provides a more robust connection.

Internally these two connectors are wired in parallel, so you can for example power the unit via the plugpack and then draw power from the screw terminals for powering external relays or sensors.

Note Switch mode power supplies can introduce noise into analog readings and are therefore not normally recommended for powering the *DT80*.

Internal Power

not applicable to DT82E/80L/85L/85GL

If the external power supply is interrupted, the *DT80* can run for a limited time on battery power.

Main battery

The DT80 and DT81/82I are fitted with an internal **6V 1.2Ah** sealed lead-acid gel-cell battery, while the DT85 uses a higher capacity **6V 4Ah** battery. It's known as the *DT80*'s "main" battery to distinguish it from the *DT80*'s other internal battery, the "memory-backup" battery.

Note The DT80G does not include an internal battery. It does, however, include the battery charger circuit so an external lead acid battery can easily be connected; see *Connecting a Larger Battery* (P222).

The main battery is completely maintenance-free and rechargeable, being automatically charged by the logger's inbuilt battery charger whenever an external power supply is connected to the *DT80*. If properly cared for (which essentially means keeping it charged), the battery should give several years' service.

Note The battery's life will be reduced if operated at temperatures exceeding 50°C.

If the main battery ever needs to be replaced, *Inside the DT80* (P217) explains how to do so.

Connect the Battery Link

The *DT80* is shipped with the main battery disconnected.

To connect the battery, all you need to do is plug the supplied 4-way terminal block into the power connector on the side of the *DT80*. The supplied terminal block includes a link which connects the **B** and **C** terminals on the power connector. This will connect up the internal battery to the *DT80* circuitry.

It is recommended that the battery link be left permanently attached to the *DT80* during operation. This guarantees uninterrupted data acquisition and logging because the internal main battery is always available to continue powering the data logger if the primary/external supply is accidentally disconnected or fails.

Main Battery Life

The length of time that the *DT80* can operate using its internal battery depends on many things, such as:

- scan interval
- number and types of channels being scanned
- volume of RS232/USB/Ethernet communications
- power management settings (e.g. sleep mode timeouts)
- sensor excitation requirements
- condition of internal battery and ambient temperature

For the DT80/81/82I (1.2Ah internal battery), a new, fully charged battery will typically run the logger for between 3 and 3000 hours (4 months), depending on the above factors. The DT85's power consumption is similar to the DT80/81/82I, so its 4Ah battery can be expected to last 3-4 times longer.

The scan interval is the main determinant of battery life. For a continuous schedule with some analog channels, the battery life would typically be about 3 hours; for a 5 second schedule it would be about 24 hours; while for sample intervals of 1 hour or greater the battery would typically last for up to 4 months.

In order to properly estimate the expected battery life, it is necessary to calculate the *DT80*'s average power consumption for the particular application. This is discussed further in *Power Consumption* (P226).

Connecting a Larger Battery

To extend the time that the *DT80* can run whilst on battery power, a larger capacity battery can be connected externally. (This is also applicable for the DT80G, which does not include an internal battery.) There are two main options, which are discussed below.

1. External Battery Charged by Logger

An external **6V lead acid** battery (max capacity **4Ah**) may be connected between the **C** and **–** terminals. This will connect the battery to the output of the *DT80's* charging circuit. An external power supply should then be connected to the **+** and **–** terminals (or DC power socket).

Note To prevent excessive current flows between the batteries, the internal battery should always be disconnected from the

charging circuit when an external 6V battery is used. This can be achieved either by:

- not connecting the battery link between the **B** and **C** terminals (*Figure 86*), or
- connecting the link between the **B** and **C** terminals but disconnecting the internal battery connector (*Figure 87*). If desired the internal battery can then be removed altogether. This is the preferred option because then the **VBAT** channel type can be used to monitor the state of the external battery; see *Monitoring DT80 Power* (P226).

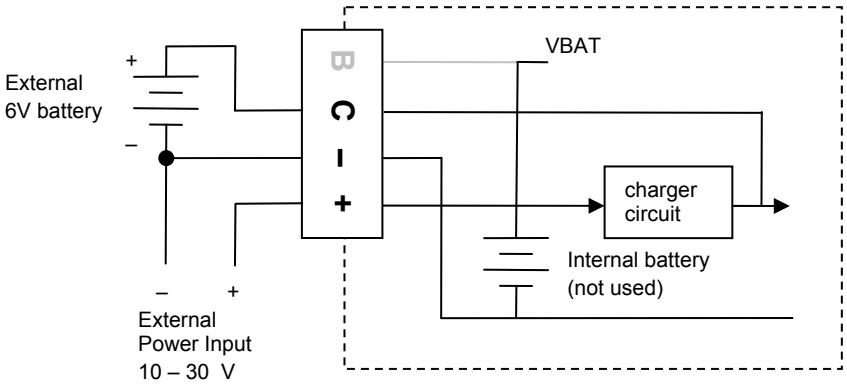


Figure 86: Connecting an external 6V battery – battery link removed

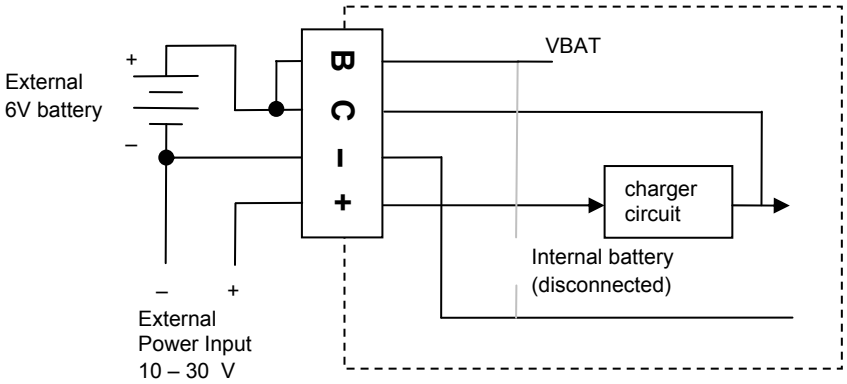


Figure 87: Connecting an external 6V battery – internal battery disconnected or removed

Note that larger capacity batteries will take longer to charge.

Note also that this configuration is not useful for a DT85 because it already includes a 4Ah internal battery.

Note The *DT80's* charging circuit includes temperature compensation. For this to be effective, the external battery and the *DT80* must be at a similar ambient temperature.

2. External Battery with External Charger

In this case an external **6V** battery (any type and capacity) is again connected to the **C** and **–** terminals. However this time an external power supply is not connected. The battery is therefore the primary power source for the logger.

As with Option 1, the internal battery must be disconnected, either by not connecting the battery link or by unplugging the internal battery connector (the latter scenario is shown in the diagram below).

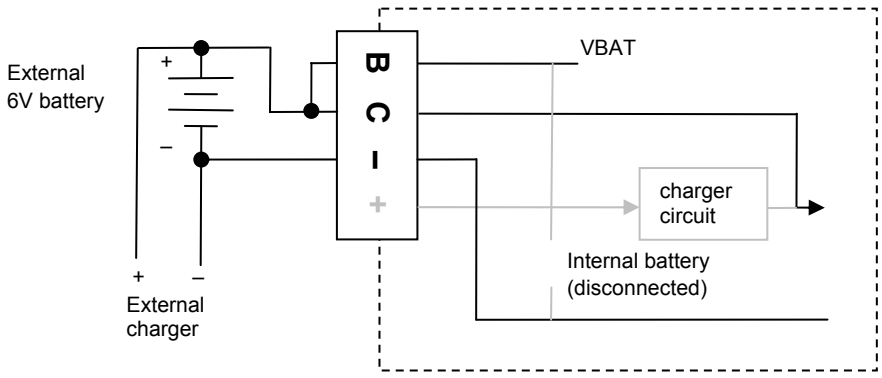


Figure 88: Connecting an externally charged 6V battery – internal battery disconnected or removed

In most cases, an external 12/24V battery system connected to the logger's external power input is preferable to an externally charged 6V battery. This is because it allows the internal battery to act as an Uninterruptible Power Supply (UPS)

and keep the logger running if the external supply is temporarily interrupted. Also, the **PWR OUT** (DT80 Series 2 and DT85 only) power output will not be available when running from 6V.

The 6V option is, however, the most power-efficient way to run the logger. See *Power Consumption* (P226) for more details. It can therefore be useful in emergency situations where normal power is not available. In these cases the logger could be powered for a limited time by connecting 4 x 1.5V alkaline cells, for example.

Storage

If the *DT80* is not to be used for a period of time, consideration needs to be given to the health of its internal battery.

Important Avoid storing the internal battery in a discharged state. If a gel-cell battery remains flat for any length of time, its capacity and service life will be significantly reduced.

Before placing a *DT80* into storage, you should therefore ensure that the main battery is fully charged (at least eight hours charge time). The battery link should then be disconnected.

Other Considerations

The main battery is a "sealed" type; however it does contain a regulator valve on its top face near the terminals. This has the following implications:

- Ventilation must be provided to allow any battery gases to escape. If the *DT80* is mounted in a sealed enclosure then a valve should be provided to prevent gas build-up.
- When operating at high temperatures, acid may seep from the regulator valve if it is facing downward. The internal battery's terminals face the rear panel of the *DT80*. The logger should therefore be oriented either in table top configuration (keypad/display facing up), or wall mounted (input terminals facing down). It should not be wall mounted upside down (input terminals facing upwards) because then the battery terminals and regulator valve would face downward.

Power Outputs

As shown in *Figure 84*, the *DT80* provides various general purpose power outputs.

Standard Outputs

For the following power outputs the return terminal is **DGND**.

- The **PWR OUT** terminal (DT85 only) provides a current limited power output derived from the external power input. The output voltage will be 1-2V below that of the external power input. If you attempt to draw more than the rated maximum current then the voltage output will drop.
- The **12V** terminal (not DT80/81 Series 1) provides a switched regulated 12V output (max 150mA). Unlike **PWR OUT**, this power is available even if the logger is running on battery power.

These power outputs may be used to power such devices as:

- CEM20 channel expansion modules (see *The CEM20* (P302))
- relays (see *DO1 – Driving a Relay* (P265))
- SDI-12 sensor networks (see *SDI-12 Channel* (P272))
- modems (see also *Powering the DT80's Modem* (P177))
- application-specific digital interfaces

Note The plug pack supplied with the *DT80* is rated at 15V 800mA (12W). However this may be insufficient for a DT85 with fully loaded power outputs and a flat internal battery, in which case a higher capacity power supply may be required. See *Power Consumption* (P226) for more details.

Isolated Output

The Series 3 models also provide an isolated switched 5V output, **5V SW**. The return terminal for this power output is **AGND**.

This output is typically used for powering analog sensors.

Controlling 12V Power Output

The switched 12V output may be controlled in three different ways:

- It may be switched on or off manually using the **PWR12V** (or **1SSPWR**) channel type. Use **PWR12V=1** to switch on the 12V output, or **PWR12V=0** to switch it off.
- It may be switched on automatically prior to execution of a schedule containing CEM20 channels. (As noted in *Powering the CEM20* (P304), any connected CEM20 units are normally powered using the 12V output.)
- It may be switched on or off automatically if the *DT80* is configured to power a modem using this power output, as described in *Powering the DT80's Modem* (P177).

Parameter P28 is used to control the behaviour of the 12V output.

P28	Description	Scenarios
P28=0 *default*	Auto CEM20 power control: *DT80* ensures that 12V is switched on prior to execution of a schedule that contains CEM20 channels. 12V will be switched off at the end of the schedule (unless there is another schedule due which requires it)	• 12V output is used to power CEM20s
P28=1	12V output is switched on all of the time	• 12V output is used to power other equipment • 12V output is used to power CEM20s and you wish to avoid the 50ms warm up delay which occurs each time the 12V output is switched on
P28=2	12V output is switched on all of the time, even when asleep	• 12V output is used to power other equipment which needs to remain powered even if *DT80* is asleep (e.g. a dial-in modem)
P28=3	12V output is not changed	• 12V output to be controlled explicitly, using **PWR12V=** • CEM20s are assumed to be independently powered

The current state of the 12V output can be queried at any time sending **PWR12V**.

Controlling 5V Power Output

Use **PWR5V=1** to switch on the isolated 5V power output, and **PWR5V=0** to switch it off.

Note The 5V output is derived from the analog power supply, so it will only be on if the analog section is powered. By default, the *DT80* analog section is only powered while a measurement is being taken. If you require the 5V output to be on continuously then it is necessary to set **P21=1** so that the analog section is continuously powered. See *Analog Measurement System* (P230) for more details.

Internal Memory-Backup Battery

In addition to the internal main battery, the *DT80* contains a small lithium "memory-backup" battery.

The memory-backup battery maintains the *DT80*'s clock/calendar and certain memory settings. (Note that the *DT80*'s internal file system, which stores programs and logged data, uses non-volatile flash memory. This does not depend on the memory-backup battery.)

Replacing the Battery

Under normal operation the memory-backup battery should last approximately five years, or approximately one year if there is no other power to the *DT80* (i.e. both external power and the main battery are disconnected).

See *Inside the DT80* (P217) for details on how to remove and replace the internal memory-backup battery. The memory-backup battery is a ½AA size 3.6V lithium type (for example, SAFT LS 14250). It's important that 3.6V and not 3.0V types be used (both types are the same physical size).

Storage

If the *DT80* is to be placed in long term storage, it is recommended that the memory-backup battery be removed, to keep it from discharging. When disconnected, the battery has a 10-year shelf life.

Monitoring *DT80* Power

The *DT80* provides a number of internal channel types for monitoring the various power systems. These can be queried at any time or used in alarms, like any other channel type.

The following channel types are available:

Channel Type	Units	Description
VEXT	V	External power supply voltage
VBAT	V	Main battery terminal voltage (5.6V or lower indicates that internal battery is flat)
IBAT	mA	Instantaneous main battery current – positive if charging, negative if discharging
VLITH	V	Memory-backup battery voltage

Note that **VEXT** will read about 1V under the actual input voltage, due to a series diode.

Power Consumption

The *DT80* incorporates a number of power management features which aim to minimise the overall power consumption. This section discusses how to estimate the average power consumption of the *DT80* in a given application, and gives some guidelines on how to configure the *DT80* for minimum power usage.

Power Consumption

Power States

At any point in time the *DT80* is in one of three power states:

- **Active** – the *DT80*'s microprocessor is running at full speed, actively performing a computation. Power usage is highest when in this state.
- **Idle** – processor is idle; running at reduced speed and waiting for something to happen. The *DT80* automatically and instantly switches between idle and active mode as required. Power usage is reduced by about 70% in this state.
- **Sleep** – processor and most other hardware is powered down. The *DT80* will automatically "wake up" when certain events occur (see *Sleep Mode* *(P231)*), a process which typically takes about 800 ms. Power usage is lowest in this state – as low as 2mW when running from the internal battery.

Power Source

The *DT80* uses the least amount of power when it is running from the internal battery.

When external power is connected, there will be some losses in the *DT80*'s internal power supply and battery charger, so the overall power consumption will be higher. These losses will increase as the external voltage increases.

The following table gives an indication of how the typical instantaneous power consumption varies according to the power source (internal/external) and supply voltage:

Power state	*DT80* Battery power (6V)	*DT80* External power (12V)	DT82E/80L/85L External Power (12V)	*DT80* External power (24V)
Active	1200 mW	1800 mW	1500 mW	2200 mW
Idle	300 mW	500 mW	400 mW	700 mW
Sleep	2 mW	60 mW	10 mW	250 mW

Table 8: DT80 *and DT82E/80L/85L core hardware instantaneous power consumption*

Notice that the DT82E/80L/85L power consumption is significantly less. This is partly due to the fact that it does not have an internal battery charger, which on the *DT80* consumes some power even if no battery is connected.

Note that the power consumption values listed above are for the core hardware only, and do not include power used by other hardware modules (within the *DT80*) which may or may not be enabled, depending on the application. These modules are described in the following section.

Hardware Modules

The following hardware modules will consume additional power whilst they are enabled:

- analog measurement subsystem
- Ethernet Interface
- LCD backlight
- battery charger
- **12V** regulated power output (not DT80/81 Series 1)
- **5V SW** regulated power output (Series 3 only)

The actual power consumption of each of these will be discussed further below.

Calculating Average Power Consumption

The *DT80*'s average power consumption will depend on:

- the amount of time that is spent in each power state (active, idle and sleep), which mainly depends on the schedule sample rate and the number and type of channels being measured
- the number of analog channels being measured (sampling an analog channel will cause the analog measurement subsystem to be enabled for the duration of the measurement)
- which other hardware modules are enabled
- whether logging is enabled

Note The figures quoted below apply to the standard *DT80* series models: DT80/81/85/85G. The DT82E has considerably lower power consumption. For example, in *Table 10* the *DT80* average power consumption, when powered by an external 12V supply, approaches 60mW for slow scan rates. For the DT82E, this figure is closer to 10mW.

Step 1 – Core Hardware

The first step is to determine the average power consumption of the *DT80* core hardware – that is, excluding "non-core" hardware modules such as Ethernet or the battery charger.

Each of the following tables lists the typical power consumption of the *DT80* core hardware for various sample rates (a single time based schedule is assumed) and various numbers of analog channels (0, 5 and 30). It is assumed that logging is enabled (**LOGON**), real-time data returns are disabled (**/r**), and sleep is enabled (see *Sleep Mode* *(P231)*).

The first table indicates the average power consumption when running from the internal 6V battery, the second is for when an external 12V supply is used and the third is for an external 24V supply.

Scan rate	0 analog channels	5 analog channels	30 analog channels	300 analog channels
continuous	1200 mW	1550 mW	1520 mW	1520 mW
1 sec	320 mW	610 mW	1520 mW	1520 mW
5 sec	170 mW	250 mW	510 mW	1520 mW
10 sec	90 mW	120 mW	260 mW	1520 mW
1 min	16 mW	20 mW	45 mW	280 mW
10 min	4 mW	4 mW	6 mW	30 mW
1 hour	3 mW	3 mW	3 mW	7 mW
10 hour and above	2 mW	2 mW	2 mW	2 mW

Table 9: DT80 *core hardware average power consumption (internal battery power)*

Scan rate	0 analog channels	5 analog channels	30 analog channels	300 analog channels
continuous	1800 mW	2300 mW	2260 mW	2260 mW
1 sec	520 mW	950 mW	2260 mW	2260 mW
5 sec	310 mW	420 mW	800 mW	2260 mW
10 sec	190 mW	240 mW	430 mW	2260 mW
1 min	85 mW	90 mW	120 mW	470 mW
10 min	62 mW	63 mW	65 mW	100 mW
1 hour	61 mW	61 mW	61 mW	67 mW
10 hour and above	60 mW	60 mW	60 mW	60 mW

Table 10: DT80 *core hardware average power consumption (external 12V power)*

Scan rate	0 analog channels	5 analog channels	30 analog channels	300 analog channels
continuous	2200 mW	2800 mW	2760 mW	2760 mW
1 sec	730 mW	1250 mW	2760 mW	2760 mW
5 sec	530 mW	650 mW	1080 mW	2760 mW
10 sec	390 mW	450 mW	670 mW	2760 mW
1 min	275 mW	290 mW	320 mW	720 mW
10 min	253 mW	253 mW	255 mW	300 mW
1 hour	250 mW	250 mW	250 mW	255 mW
10 hour and above	250 mW	250 mW	250 mW	250 mW

Table 11: DT80 *core hardware average power consumption (external 24V power)*

Note that:

- At slow scan rates the logger spends nearly all of its time asleep, so the average power consumption is determined solely by the core hardware's sleep mode power consumption, which is fixed.
- If sleep is disabled, then for slow scan rates the core hardware power consumption will approach the "idle" power state value (300/500/700 mW for 6/12/24 V supply)

- For a continuous schedule, the "30 analog channels" case actually uses slightly less power than the "5 analog channels" case. This is because a greater proportion of the time is spent with the processor idle, waiting for the analog sampling to complete.
- These tables assume that the schedule contains only analog channels. Digital channels can usually be disregarded, but if there are a significant number of calculations being done then the average power consumption will increase. If any very time consuming operations are performed (e.g. reading SDI-12 sensors) then these tables are no longer applicable. Refer to *Example 3* (P229) for more information.
- A measurement made using a CEM20 channel takes approximately twice as long as a *DT80* channel. Thus if 15 CEM20 channels are sampled, you should use the values in the "30 analog channels" column above. See *Example 4* (P229).

For example, if 10 analog channels are being sampled once per minute then from *Table 10* the core hardware will draw an average of approximately 100 mW from a 12V external supply (although from *Table 8* the peak demand may be up to 1800 mW).

Step 2 – Other Hardware

The following table specifies the typical additional power required by each of the *DT80*'s "non-core" hardware modules:

Module	Powered during sleep	Battery power (6V)	External power (12V)	External power (24V)
Ethernet	no	300 mW	450 mW	550 mW
LCD Backlight	no	450 mW	650 mW	750 mW
Analog Subsystem (see note below)	no	650 mW	950 mW	1050 mW
12V Power Output	no (yes if **P28=2**)	400 mW	550 mW	700 mW
CEM20 active	no (yes if **P28=2**)	350 mW	350 mW	350 mW
12V Load (max 150 mA)	no (yes if **P28=2**)	up to 1800 mW	up to 1800 mW	up to 1800 mW
PWR OUT Load (max 300 mA)	yes	-	up to 3600 mW	up to 7200 mW
Battery charge current (max 600 mA)	yes	-	up to 3600 mW	up to 3600 mW

Table 12: Power consumption for DT80 *hardware modules*

Note that:

- The Ethernet interface is enabled by default, but may be disabled using a profile setting.
- The LCD module itself consumes negligible power, but the backlight's power usage is significant. By default, the backlight will switch off 30 seconds after the last key press.
- The Analog Subsystem figures represent the power used while performing an analog measurement. This power does not need to be added when calculating average power consumption, as it has already been incorporated into the Core Hardware calculation. It is included here to assist in calculating the peak power demand.
- The figure quoted for the 12V Power Output is the "no load" consumption which will be present whenever the power output is enabled (**PWR12V=1**, or during a CEM20 measurement). The additional power drawn by an external device connected to the **12V** output is shown separately.
- The quoted CEM20 power consumption is for when it is actively in use i.e. its relays are enabled. Only one CEM20 will be active at any one time. CEM20s which are powered but idle draw minimal power (10mW).
- The battery charge current will be close to zero once the battery is fully charged; for a flat battery it will be up to 600 mA (3600 mW).

For hardware modules which are powered during sleep mode (e.g. **PWR OUT** output), their power consumption can be simply added to the core hardware average power consumption calculated above.

For modules which are not powered during sleep mode (e.g. **12V** output) it is necessary to scale their power usage according to the percentage of time that the logger spends awake, which can be estimated from the following table:

Scan rate	0 analog channels	5 analog channels	30 analog channels	300 analog channels
2 sec and below	100%	100%	100%	100%
3 sec	24%	34%	100%	100%
5 sec	15%	20%	38%	100%
10 sec	7%	10%	19%	100%
1 min	1.2%	1.7%	3.2%	19%
10 min	0.1%	0.2%	0.3%	1.9%
1 hour	0.02%	0.03%	0.05%	0.3%
10 hour and above	0%	0%	0%	0.03%

Table 13: Approx. percentage of time spent awake

Example 1

A DT85 is powered by an external 12V supply, is running a 10 second schedule with 5 analog channels, and the **12V** power output is enabled with a 200mW load connected. The Ethernet port is disabled.

Using *Table 10*, the average power consumption for the core hardware is 420mW. We now need to add the power used by

the **12V** power output (550+200 = 750mW, from *Table 12*). But from *Table 13*, the logger spends only 10% of its time awake, so this hardware module will, on average, contribute 750 x 10% = 75mW. The overall average power consumption is therefore 420 + 75 = 495mW.

Example 2

A remote monitoring station consists of a DT80 measuring and logging 10 analog channels and 5 digital channels every 5 minutes. It is powered by a 12V solar-charged battery. The Ethernet port is disabled.

Using *Table 10*, we need to interpolate between the 5 and 30 analog channel columns, and between the 1 and 10 minute schedule rate rows. So we estimate 80 mW average power usage for a 5 minute schedule. Note that we can disregard the digital channel measurements as the power usage will be negligible compared to the analog channels. We also assume that Ethernet and the LCD backlight will be disabled, so there is no extra power usage there.

The solar panel and external battery can now be sized based on these calculated power requirements (80 mW average).

The power system (i.e. the external battery) will also need to be able to handle the peak power demand, which can be calculated by adding up the worst case instantaneous consumption figures: 1800mW (core hardware, active power state) + analog subsystem (950 mW) + internal battery charge current (3600 mW when flat). This works out to around 7W, or 600 mA @ 12V. If the *DT80* internal battery is not used, the peak power requirement will be around 3W.

Example 3

A DT85 is powered by an external 12V supply and is set up to poll a network of SDI-12 sensors every 5 minutes. It takes a total of 30 seconds to power up and read all of the sensors. The SDI-12 network is powered by the DT85's switched **12V** output, and draws a total of 800 mW. The Ethernet port is disabled.

In this case we cannot just look up the average power consumption for a 5 minute schedule with zero analog channels, because the long SDI-12 measurement will keep the logger awake for much longer.

Instead, we need to estimate how long the logger is spending in each of its power states. In this case:

- allow 2 seconds for the logger to wake up and do the actual SDI-12 communications, logging, etc. (active power state)
- allow 30 seconds of doing nothing waiting for the sensors to return values (idle power state)
- and sleep for the remaining 4 minutes and 28 seconds (268 seconds) (sleep power state).

The power consumption for each power state is listed in *Table 8* – 1800, 500 and 60 mW for the active, idle and sleep states respectively.

We also need to allow for the power drawn from the **12V** output terminal by the SDI-12 network, which will be 550 mW for the power supply plus 800 mW for the load (1350 mW total). This power output will be active for 32 seconds.

So if we average the power consumption over the 5 minute (300 second) schedule interval:

Ave Power = (1800+1350)mW x 2/300 + (500+1350)mW x 30/300 + 60mW x 268/300 = 260 mW

Example 4

80 thermocouples are connected to two CEM20 modules controlled by a DT80, and are measured once a minute. The CEM20s are powered by the *DT80*'s **12V** output. The Ethernet port is disabled.

CEM20 measurements take about twice as long as regular measurements, so this system is roughly equivalent to sampling 160 analog channels. Using *Table 10*, we estimate the average core hardware power drawn from an external 12V supply to be 300mW.

We now need to add the power used by the 12V output and the CEM20s, which will be 550+350 = 900mW, from *Table 12*). From *Table 13*, we estimate that the logger spends about 10% of its time awake, so the CEM20s will, on average, contribute 900 x 10% = 90mW. The overall average power consumption is therefore approximately 300 + 90 = 390mW.

Battery Life

Once the average power consumption for the application has been calculated, we can estimate how long the *DT80*'s internal battery will be able to keep the logger operating.

For a lead acid battery, the battery voltage is relatively constant during discharge, then drops rapidly once the battery is nearly flat. The *DT80* will automatically enter an indefinite **forced sleep** mode once the terminal voltage drops below about 5.5V. The "battery life" is therefore defined as the elapsed time between disconnecting external power and the *DT80* being forced into sleep mode.

The quoted capacity of a lead acid battery (e.g. 1.2Ah) is the energy that can be extracted from the battery at a 20 hour discharge rate. In other words if you draw 1.2/20 amps (60 mA, or 360 mW) then the battery will last for 20 hours. It does not follow, however, that if you draw 600 mA (10 times more) then the battery will last for 2 hours (10 times less). In fact it will last for closer to 1 hour.

The maximum instantaneous discharge current for a lead acid battery is typically three times the capacity, i.e. 3.6A (21W) for a 1.2Ah battery. (At this rate the battery life would be only about 3 minutes.)

At the other end of the scale (very low discharge currents), the self-discharge rate of the battery can become significant. A lead acid battery will typically lose 3% of its capacity per month at 20°C (1.5% per month at 0°C, 10% per month at 40°C).

The following table takes all these effects into account, and can be used to estimate the life of a new, fully charged 1.2Ah (DT80/81) or 4.0Ah (DT85) battery, given a calculated average power consumption:

Average power consumption from battery	Approx 1.2Ah battery life	Approx 4.0Ah battery life
5000 mW	0.5 hours	3 hours
2000 mW	2 hours	10 hours
1000 mW	5 hours	24 hours
500 mW	12 hours	48 hours
200 mW	36 hours	5 days
100 mW	3 days	10 days
50 mW	6 days	20 days
20 mW	15 days	45 days
10 mW	30 days	3 months
5 mW	1.5 months	5 months
2 mW	4 months	11 months

Table 14: Approximate lead acid battery life

The above assumes a battery ambient temperature of 20°C.

At 40°C, the battery life will be slightly improved at high discharge currents, but will be significantly shorter at low discharge currents, due to the accelerated self-discharge rate.

At 0°C, the overall battery capacity will be reduced by about 20% (compared to 20°C), so the battery life for high and mid discharge rates will be shortened. However, the self-discharge rate will also be reduced, so for very low discharge rates the battery life will be comparable to that for 20°C.

Example 5

A DT85 is set up to measure 10 analog channels every 5 seconds. How long can it run using the internal 4.0Ah battery?

The first step is to calculate the average power consumption. Using *Table 9*, we estimate the core hardware power consumption at 300mW for a 5 second schedule with 10 analog channels. No other hardware modules (e.g. Ethernet) are used, so we take this value as the overall power consumption.

Using *Table 14*, we see that at 300 mW the battery life should be around 3-4 days.

Example 6

A DT80 is powered by the supplied 15V plug pack and every 10 seconds it reads 2 analog channels and polls a serial sensor (which we assume has its own battery backed power supply). Communications with the host computer use the Ethernet interface. For how long will the logger be able to run in the event of a mains power failure?

The Ethernet interface is enabled, so the *DT80* will normally not sleep, as going to sleep will cause any network connections to be disconnected. We therefore cannot use *Table 9* to estimate average power consumption, because this table assumes that the logger will sleep between scans.

Instead, we will assume that the *DT80* spends:

- 1 second doing the communications and measurements, logging the result etc. (active power state, analog subsystem enabled, Ethernet enabled)
- 9 seconds waiting for the next scan to come around (idle power state, analog subsystem disabled, Ethernet enabled)

Using *Table 8*, the average core hardware power consumption when battery powered will be 1200mW while active and 300mW while idle. Using *Table 12*, the analog subsystem will add 650mW while enabled, and Ethernet adds 300mW.

Putting this all together:

Ave Power = (1200+650+300)mW x 1/10 + (300+300)mW x 9/10 = 755 mW

Finally, from *Table 14* we see that the DT80's 1.2Ah battery should keep the logger running for about 8 hours.

Minimising Power Consumption

In order to minimise power consumption, the general aims are to:

- disable hardware modules which are not required, and
- maximise the time spent in the "sleep" power state (see *Sleep Mode* (P231))

Disable Unnecessary Hardware

Analog Measurement System

Setting **P21=0** (which is the default) will minimise power consumption. When an analog measurement is due, the analog subsystem will be switched on, then the *DT80* will wait 50 ms for it to stabilise and then take the measurement. The analog power will remain on until there are no more schedules to execute; hence any subsequent analog measurements in the schedule or any other schedule due to be executed at the same time will not include this 50ms delay.

For high speed sampling, where power consumption is less of a concern, it is preferable to set **P21=1**. In this case the analog subsystem remains powered all the time (except in sleep mode), which removes the need for the 50ms delays. For situations where the logger stays awake all the time, this setting will also minimise differences between readings due to the analog section's warm-up characteristic, which can take a few minutes to fully stabilise (see *Analog Warm Up Time* (P299)).

CEM20

Setting **P28=0** (which is the default) will cause the CEM20 power (i.e. the *DT80* **12V** output) to be managed in a similar way to the analog subsystem power when **P21=0**. That is, the power output will be switched on only during schedules which include a CEM20 analog measurement.

Ethernet Port

The Ethernet interface is enabled by default, and will consume power even if no Ethernet cable is connected. If Ethernet connectivity is not required then the port should be disabled, as follows:

```
PROFILE ETHERNET ENABLE=NO
```

Serial Ports

The serial ports also use a small amount of power while idle, so if they are not required then they can be disabled, too:

```
PROFILE SERSEN_PORT FUNCTION=DISABLE
PROFILE HOST_PORT FUNCTION=DISABLE
PROFILE USB_PORT FUNCTION=DISABLE
```

LCD Backlight

Parameter P20 controls the operation of the LCD backlight. By default (**P20=2**), it will switch on when there is user activity (e.g. key pressed, or USB cable inserted), then switch off a short time (P17 seconds) later. This should be adequate for most applications. For minimum power usage it can be forced to be always off by setting **P20=0**.

Maximise Sleep Time

The following guidelines will help maximise the time that the logger spends asleep, thereby minimising power consumption:

- Scan as slowly as possible – don't scan every minute if you only need to scan every 5 minutes
- Align schedule intervals to minimise the number of wakeups, even if this means that some schedules sample more frequently. For example:

  ```
  RA40S 1V  RB20S 2V
  ```

  is generally better than

  ```
  RA40S 1V  RB30S 2V
  ```

  because the two schedules are more likely to be processed together.
- Reduce the **P17** setting (delay before entering sleep mode, seconds), say **P17=5**, so that if a wakeup event does occur, the logger will go back to sleep quickly.
- Consider reducing the **P4** setting (wake-up latency, ms), say **P4=100**. This will result in the *DT80* allowing less time for the wake process than it actually takes, so it will therefore be able to sleep a little longer. Following wake, the *DT80* will now not have to wait for the schedule's appointed time to come around – it will have already passed. The schedule will then be executed immediately, albeit slightly late.
- It is normally not recommended to change the **P3** (minimum sleep time) setting. Sleeping for periods shorter than 1.5 seconds is generally counter-productive: the additional processing time associated with waking up outweighs the lower sleep mode power usage, leading to a net increase in the average power consumption.

Sleep Mode

The *DT80* has a low power **sleep mode** that significantly reduces the power consumption – to as low as 2 mW when running from the internal battery. While asleep no measurements or processing can be done, but the state of the current job is preserved. The *DT80* will automatically wake from sleep when a measurement is due, or some other event occurs.

About Sleep Mode

While the *DT80* is asleep:

- The LCD and all front panel LEDs are switched off.
- All communications ports (Ethernet, USB, serial) are disabled. Any USB or TCP/IP connections will be disconnected when the logger goes to sleep and will need to be re-established by host software after the logger wakes.
- Digital output states and the state of the latching relay are maintained.
- Digital inputs are not scanned – transitions will not wake the logger, trigger schedules or be counted by low speed counter channels (**1..4C** channel types).
- Pulses on the high speed counter inputs (**1C**-**4C** terminals, **1..4HSC** channel types) will be counted, without waking the logger. As discussed in *Counting While Asleep* *(P269)*, it is necessary to wake the logger periodically using a timed schedule to ensure that the 16-bit hardware counters do not overflow.
- The **12V** power output (DT80 Series 2 and DT85 only) is switched off.
- The **PWR OUT** power output (DT80 Series 2 and DT85 only) will still be available, assuming that the logger is externally powered.

- All parameter settings, CV values, comms port settings and other job-related state information is preserved.

Wake Events

Once asleep, the *DT80* will stay that way until one of the following events occur:

- a timed schedule becomes due
- a keypad button is pressed
- the **WK** (wake) input terminal is pulled to logic low
- a character is received on the serial sensor port, or there is a transition on the CTS line
- external power is connected
- a USB communications cable is connected
- a character is received on the host RS232 port

Any of these will cause the *DT80* to wake. If the reason for waking was a timed schedule, the *DT80* will execute the schedule, then immediately go back to sleep (if there are no other schedules due within the next few seconds). During this time the LCD and backlight will remain off.

For all other wake sources, the *DT80* will stay awake for at least the period specified by parameter **P17** (default 30s). This timer will be reset if any further wake events occur, or if data is received on any comms port. Once the timer expires the *DT80* will go back to sleep.

Note also that:

- Event triggered schedules (i.e. schedules triggered by digital input transitions, counters, serial data or CV values) will not cause the logger to wake. Only timed schedules will cause a wake up.
- If the *DT80* is woken by receipt of RS232 data on the host or serial sensor port, the first character (and possibly some of the following ones) will be lost. You should therefore always send a dummy character (e.g. LF) to wake the *DT80*, then wait about one second before sending the first actual command.

Controlling Sleep

By default, the *DT80* will not go into sleep mode if any of the following are true:

- a schedule or command is being executed, or is due to execute soon
- the Ethernet port is enabled and a cable is connected
- a USB cable is connected
- a PPP session is currently active
- a job has been partially entered
- there has been "activity" (e.g. key press, command, Modbus/web/FTP request) within the last **P17** seconds

Note that any Ethernet and USB connections are terminated whenever the *DT80* goes to sleep – which is why the *DT80* will by default disallow sleep while either of these ports are connected.

Some of the above conditions can be overridden using the **P15** parameter, as follows.

Conditions P15	Power Source	USB port	Ethernet port	*Result*
P15=0 (default)	battery	not connected	not connected or disabled	Allow sleep
P15=1	x	not connected	not connected or disabled	Allow sleep
P15=2	x	x	x	Do not allow sleep
P15=3	x	x	x	Allow sleep
P15=4	battery	x	x	Allow sleep

x = "don't care"

For example, if you set **P15=3** then the *DT80* will be allowed to go to sleep, even if the logger is externally powered or Ethernet/USB is connected.

Forced Sleep Mode

The *DT80* provides some protection against gradual power failure (e.g. the internal battery becoming discharged). If it detects that the supply voltage is becoming critically low (terminal voltage less than about 5.5V), the *DT80* will automatically close all store files and force the unit into sleep mode. The *DT80* will remain asleep until the power supply recovers to an adequate level. During this time schedules will not execute.

Once power is restored, a hard reset will occur.

An entry will be added to the event log *(P213)* any time that the *DT80* enters forced sleep mode.

Part N – Sensors & Channels

Overview

This section describes how to use the *DT80*'s analog, digital and serial inputs to measure many different physical quantities. The focus here is on the measurement process – connecting up a sensor and successfully reading it.

The following topics are covered for each sensor type:

- an overview of how a measurement is made
- wiring configurations – how to physically connect to the *DT80*'s input terminals. For reference, each wiring configuration presented here is given a number, e.g. "V1" for voltage wiring #1.
- the applicable *DT80* **channel types** and **channel options** – that is, how to program the *DT80* to read the particular sensor or measure the particular quantity.

This section also includes some general information about how the *DT80*'s analog measurement system works, and how to get the best out of it.

What Can Be Measured?

Analog channel types:

- voltage
- current and current loops
- resistance
- ratiometric resistance (bridges)
- temperature – thermocouples, thermistors, RTDs and IC sensors
- frequency
- strain gauges – bridges, vibrating wire, Carlson sensors
- logic state

Digital channel types:

- digital inputs
- digital outputs
- pulse counters – standard and high speed
- phase encoder (quadrature) inputs

Serial channel types:

- SDI-12
- generic serial sensors

Analog Channels

For detailed specifications, see *Analog Inputs* (P306).

About the Analog Input Terminals

Each of the *DT80*'s analog inputs has four terminals: ***** (Excite), **+** (Plus), **–** (Minus) and **#** (Return).

Any analog measurement involves at least two terminals: a signal terminal and a return terminal. At the core of most measurements is a voltage measurement between these two terminals.

To specify which terminals to use, the **channel type** (**V**, **TK**, **BGI** etc.) is prefixed by an **input number** (**1**, **2**, **3** etc.) and a **terminal specifier**.

The terminal specifier can be either:

- nothing : measure between + and – terminals,
- ***** : measure between * and # terminals,

- **+** : measure between + and # terminals,
- **–** : measure between – and # terminals, or
- **#** : measure between # and AGND/EXT# terminals

For example, the command **3+V** causes the *DT80* to measure the voltage between the + and # terminals on analog input 3, while **1R** means measure the voltage between + and – on analog input 1 (which will then be used to calculate the unknown resistance, provided it is connected as shown in the wiring diagrams).

A particular channel type will not necessarily support all of the above terminal specifiers. For example, the **#** specifier is only available for current-based channel types.

Voltage

Voltage (difference in electrical potential) is the fundamental quantity that is measured during any analog measurement.

The *DT80* measures a voltage by:

1. connecting the required input terminals to the instrumentation amplifier by closing the appropriate input relays and selecting input attenuators if required;
2. converting the amplified signal to a frequency using a precision Voltage Controlled Oscillator (VCO);
3. digitally measuring the frequency and calculating the resultant voltage reading;
4. possibly repeating steps 2 and 3 using a different amplifier gain setting if required.

Note Because all analog measurements (including current, resistance, thermocouple, etc.) are fundamentally voltage measurements, much of the information in this section is applicable to them, too.

Channel Types

The following channel types will directly return a voltage value:

Channel Type	Description	Units
V	voltage, attenuators disabled by default (max input 3V)	mV
HV	voltage, attenuators enabled by default (max input 30V)	V

For example, to measure the voltage between the * and # terminals on analog input 2 you would include the channel definition **2*V** in your *DT80* program (or, to make a single "immediate" measurement, simply send **2*V** to the *DT80*'s command interface, e.g. by typing it into the *DeTransfer* send window).

Channel Options

The following channel options are commonly used when measuring voltages:

- **GL30MV**, **GL300MV**, **GL3V** and **GL30V** (gain lock) allow the *DT80*'s input gain to be locked on a particular range. See *Gain Ranges and Attenuators* below.
- **A** (attenuator) and **NA** (no attenuator; default) allow the *DT80*'s 10:1 input attenuators to be switched in or out. See *Gain Ranges and Attenuators* below.
- **ES***n* (extra samples) specifies that *n* additional measurements should be taken and the result averaged. This can help with very noisy signals.
- a **channel factor** (a floating point number) can be specified as a simple scaling factor. The measured voltage will be multiplied by this factor before being returned. For more advanced scaling options, see *Manipulating Data* *(P60)*.

Gain Ranges and Attenuators

The *DT80*'s instrumentation amplifier has three switchable gain settings. These give three basic voltage measurement ranges (30mV, 300mV and 3V full scale).

The analog inputs also include switchable 10:1 **attenuators**, which effectively provide a fourth range (30V).

By default the appropriate gain range is selected automatically. The first time a channel is measured, the *DT80* will select the highest input range (3V if attenuators are not enabled, 30V if they are). If the reading is close to zero then up to two additional measurements will be made on progressively lower input ranges.

For subsequent measurements of the same channel, the *DT80* will initially use the same input range as was used previously. If the reading is overrange or close to zero then the input range will be adjusted up or down respectively and the measurement repeated.

The auto-ranging process may therefore cause the time taken to sample a channel to be increased on occasion. To avoid this, the gain can be locked on a particular setting, using the **GL***x* channel options.

Note that auto-ranging does not affect the attenuator setting. Each channel definition command specifies (either implicitly or explicitly) whether the attenuators should be on or off.

The following table summarises all possible gain/attenuator options

Channel definition	Attenuators	Input range	Units
1V	off	auto 30mV, 300mV, 3V	mV
1V(GL30MV)	off	30mV	mV
1V(GL300MV)	off	300mV	mV
1V(GL3V)	off	3V	mV
1V(GL30V)	*error*		
1V(A)	on	auto 300mV, 3V, 30V	mV
1V(A,GL30MV)	*error*		
1V(A,GL300MV)	on	300mV	mV
1V(A,GL3V)	on	3V	mV
1V(A,GL30V)	on	30V	mV
1HV	on	auto 300mV, 3V, 30V	V
1HV(GL30MV)	*error*		
1HV(GL300MV)	on	300mV	V
1HV(GL3V)	on	3V	V
1HV(GL30V)	on	30V	V
1HV(NA)	off	auto 30mV, 300mV, 3V	V
1HV(NA,GL30MV)	off	30mV	V
1HV(NA,GL300MV)	off	300mV	V
1HV(NA,GL3V)	off	3V	V
1HV(NA,GL30V)	*error*		

Warning Maximum input voltage on any analog input is ±35V dc, relative to the **AGND/EXT#** terminal. If this is exceeded then permanent damage may occur.

Input Configurations

By definition, a voltage is a measurement between two points. Multiple separate voltage measurements can share a common reference point, or each measurement can have an independent reference point.

The reference point, be it shared or unshared, need not be at ground potential. All voltage measurements made by the *DT80* are therefore **differential** measurements – they measure only the difference in voltage between the two terminals.

Another way of looking at it is that the *DT80* will reject (ignore) the terminals' **common mode voltage** – that is, the voltage that is common to both terminals. So if a channel's + terminal is at 7V (relative to the *DT80*'s analog ground) and the – terminal is at 5V then the **1V** channel will return a value of 2V. The common mode voltage (5V) has been rejected.

Important The *DT80* can effectively remove the unwanted common mode component from the input signals provided that the common mode limits for each terminal is not exceeded (max. ±3.5V/35V for attenuators off/on, relative to the *DT80's* analog ground). Note that because the *DT80*'s analog ground is isolated, it can normally "float" up to match whatever common mode voltage is present on the sensor being measured, thereby keeping the common mode voltage seen by the *DT80*'s amplifier within limits.

Shared-Terminal Inputs

In a shared-terminal configuration, a sensor's "return" or "negative" wire is usually connected to the channel's **#** terminal, as shown in *V1 – Shared-Terminal Voltage Inputs* (P236). The remaining sensor wire (the "positive" or "signal") is connected to any of the channel's other three terminals.

Each of the *DT80*'s analog inputs can therefore support up to three shared terminal voltage inputs.

For shared-terminal inputs, the channel number is given a suffix indicating the terminal to which the positive wire is connected. For example, the channel definition **1+V** specifies a shared-terminal voltage input applied to channel 1 between the + and # terminals (and likewise **1*V** and **1-V**).

Independent Analog Inputs

An independent, or "unshared" input is one that connects to its own terminals and does not share any of those terminals with any other inputs. As shown in *V2 – Independent Voltage Inputs* (P236), each analog input can support up to two independent voltage inputs – one between the + and – terminals (**1V**) and one between * and # (**1*V**).

For the DT80 Series 2 and DT85, these two independent inputs (i.e. **1V** and **1*V**) operate identically. For the DT80/81 however, they have slightly different characteristics. In particular, referencing a measurement to the # terminal (i.e. the **1*V** configuration) provides a better ground reference, so in most cases it is preferred. See *Input Termination* (P298) for more details.

Analog Input Isolation

The *DT80* uses relay multiplexers to switch input channels through to the instrumentation amplifier one at a time. All four terminals of each analog input channel remain disconnected from the *DT80*'s electronics, except when that channel is being measured. This means that each analog input channel is totally isolated from any other input channel.

What about the case where two independent inputs are connected to a single analog input channel?

For the DT80/81 Series 1 , these two "independent" inputs are in fact not completely isolated from each other. This is because for these logger models, all four terminals for a given channel are switched together. So if you are measuring **1V** (voltage between + and – input terminals), bear in mind that the * and # terminals will also be connected to the *DT80* circuitry.

This may cause problems if the two sensors have significantly different common mode voltages. If this is the case then they should be connected to separate input channels.

For the DT80 Series 2 and DT85, the two pairs of input terminals (+ - and * #) can be switched independently. This means that when doing a **1V** measurement, the * and # terminals remain isolated. Similarly, when doing a **1*V** measurement, the + and – terminals remain isolated. The upshot of this is that sensor V1 (*Figure 90*) could have 10V common mode voltage and sensor V2 could have -2V common mode and both would still be measured correctly. On a DT80/81, these two sensors would need to be connected to separate channels (e.g. **1V** and **2V**).

V1 – Shared-Terminal Voltage Inputs

In this configuration up to three separate voltage inputs can be connected to one analog input channel. The **#** terminal acts as a shared common. See *Shared-Terminal Analog Inputs* *(P20)*

Shielded cable may be helpful when the signal has a high output impedance or when noise pickup from other cables is a problem. Ensure that the shield is only connected to ground at one end of the cable, either to a **DGND** terminal or the earth point on the side of the *DT80* case.

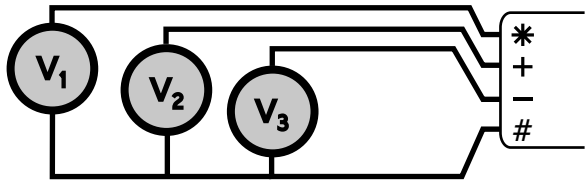


Figure 89: Wiring for shared-terminal voltage input

To measure	Use the command
V1	**1*V**
V2	**1+V**
V3	**1–V**

V2 – Independent Voltage Inputs

In this configuration each voltage measurement is independent of any other (no wires are shared). The trade-off is that at most two voltages can be measured per analog input channel.

For the DT80 Series 2 and DT85, the two measurements are completely isolated – while measuring V1, V2 is disconnected, and vice versa.

This is not the case, however, for the DT80/81, where both voltage sources will be connected to the logger electronics (and therefore referenced to the logger's analog ground) when either is being measured. This can cause measurement errors if the two inputs have significantly different common mode voltages. See *Input Switching* *(P297)*.

As with shared terminal inputs, a cable shield may be helpful when the signal has a high output impedance or when noise pickup for other cables is a problem. Ensure that the shield is only connected to ground at one end of the cable, either to a **DGND** terminal or the earth point on the side of the *DT80* case.

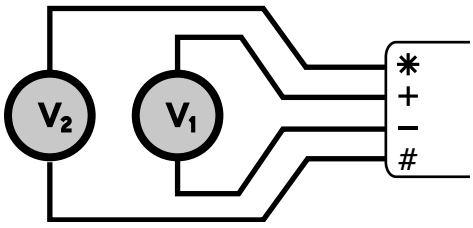


Figure 90: Wiring for independent voltage input.

To measure	Use the command
V1	**1V**
V2	**1*V**

Current

Current (rate of electrical charge movement) is measured by inserting a known **shunt** resistance into the circuit, and measuring the voltage across it. Using Ohm's Law, Current = Voltage / Resistance.

The **I** channel type returns the current value in milliamps (mA).

The *DT80* incorporates an internal 100Ω shunt resistor between the **#** terminal and analog ground. Alternatively, an external shunt may be used. The value of the external shunt must be known and must be specified when the channel is defined.

For example, the channel definition **3#I** will measure the current which enters at channel 3's **#** terminal, flows through the internal shunt, and returns via the **AGND/EXT#** terminal.

On the other hand, **2+I(51.2)** will return the current flowing through a 51.2Ω shunt wired between the **+** and # terminals of channel 2.

Channel Options

The following channel options are commonly used when measuring currents:

- **A** (attenuator) specifies that the *DT80*'s input attenuator should be enabled, which allows voltages of up to 30V to be measured across the shunt resistors. Note that this option is not available if the internal shunt is used.
- the excitation options specify how the current source is powered: **N** (assume external power supply; default), **V** (enable internal 4.5V voltage source on * terminal) or **E** (assume external supply connected to **EXT*** terminal).
- **E** (external excitation) specifies that the power supply for the current sources is connected to the *DT80*'s **EXT*** terminal. This will then be automatically connected to each current source for the duration of a measurement, then disconnected.
- **MD***n* (measurement delay) specifies that the *DT80* should wait *n* ms (default 10ms) after selecting a channel before starting the actual measurement. This can be useful in conjunction with the **E** option, as it allows the sensor some time to stabilise after power is applied to it.
- the **channel factor** specifies the shunt resistance in ohms (default 100.0 Ω)
- **GL***x*, **ES***n*, as for voltage measurements

The following sections describe some common wiring configurations for measuring current.

C1 – Shared-Terminal Current Inputs with External Shunts

In this configuration up to three separate current sources can be measured. This is done by measuring the voltages across the shunts in the shared terminal configuration; see *V1 – Shared-Terminal Voltage Inputs* (P236).

To avoid cross-channel coupling, connect the bottom of the shunts with the minimum of shared resistance to the sense point.

The resistance of each shunt should be specified as the channel factor.

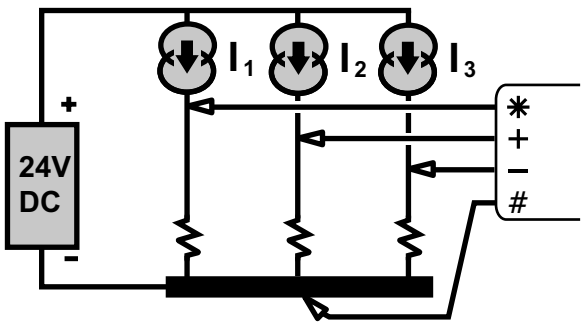


Figure 91: Wiring for shared-terminal current input using external shunt

To measure	Use the command
I1	**1*I(***R1***)**
I2	**1+I(***R2***)**
I3	**1-I(***R3***)**

C2 – Independent Current Inputs with External Shunts

In this configuration up to two separate current sources can be measured. This is done by measuring the voltages across the shunts in the independent terminal configuration; see *V2 – Independent Voltage Inputs* *(P236)*

The resistance of each shunt should be specified as the channel factor.

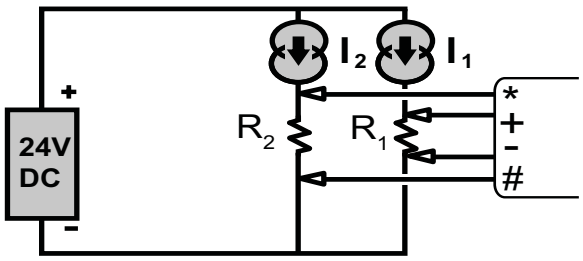


Figure 92: Wiring for independent-terminal current input using external shunts

To measure	Use the command
I1	`1I(R1)`
I2	`1*I(R2)`

C3 – Independent Current Input using the internal shunt

In this configuration the *DT80*'s internal 100 Ω shunt resistor is used. The internal shunt resistor is connected between the channels **#** terminal and **AGND** (**EXT#** on DT80 Series 2/DT85).

Note that input attenuation is not available for # terminal measurements. This means that the maximum current that can be measured using the internal shunt is approximately 30mA. For higher currents, or situations where the common mode voltage relative to analog ground exceeds 3V, it will be necessary to use an external shunt.

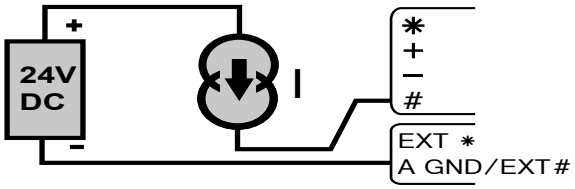


Figure 93: Wiring for Independent current input using internal shunt

To measure	Use the command
I	`1#I`

C4 – Independent Current using internal shunt and switched excitation

In this configuration the *DT80* switches a single excitation supply through to each channel as it is measured (this means that between measurements the current source will be unpowered).

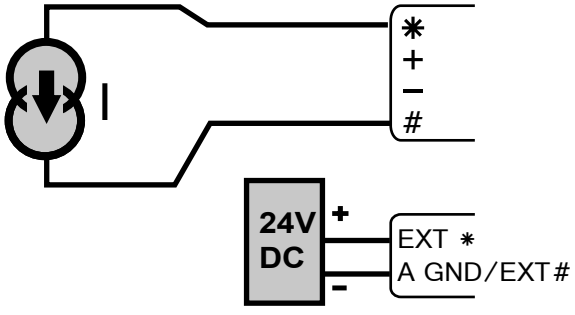


Figure 94: Wiring for independent current using internal shunt and external excitation

To measure	Use the command
I	`1#I(E)`

4–20mA Current Loops

Many different sensor types provide a 4-20mA current output, where the current is proportional to the quantity being measured.

The channel type for a 4-20mA current loop measurement is **L**; channel options are as for Current measurements; see *Current* (P237).

To read a current loop sensor, the *DT80* first measures the current. Any of the *Current* wiring configurations may be used. The measured current is then scaled so that the channel returns 0% for 4mA and 100% for 20mA.

For example, if a current loop sensor is connected as per *C3 – Independent Current Input using the internal shunt* (P238) then it would be read using **1#L**.

A span is often applied to this value so that the final reported value is in the proper engineering units for the quantity being measured.

For example, if a pressure sensor with 4-20mA output operates over a range of 100-500kPa then

```
BEGIN S1=100,500"kPa" RA2S 4#L(S1) END
```

will return a pressure reading in kPa every 2s. The loop would in this case be connected across the **4#** and **AGND/EXT#** terminals, making use of the internal shunt resistor.

One advantage of a current loop system is that a cable fault can be readily detected. An open circuit loop will give a negative reading, normally -25% (0mA), which can then be detected in an **ALARM** statement.

Multiple Devices in One Loop

Multiple measurement devices can be connected in series in the one current loop. For example, a current loop might include both a *DT80* and a 4-20mA digital panel display module, in series. (There can only be one 4-20mA sensor in a given loop.)

In these situations care needs to be taken to ensure that the *DT80*'s common mode voltage limits are not exceeded, especially if the *DT80* is placed "above" the other devices in the loop. The *DT80*'s input attenuators may be enabled using the **A** channel option, which will increase the common mode limit to ±35V, relative to **AGND/EXT#**

Note If there are multiple devices in the loop then the loop should be continuously powered. This implies the use of an external shunt (*C1 – Shared-Terminal Current Inputs with External Shunts* (P237)), as the *DT80* normally disconnects the **EXT#** terminal between measurements.

Resistance

Resistance (degree of impediment to current flow) is measured by passing a known **excitation current** through the resistance and measuring the voltage across it. From Ohm's law, Resistance = Voltage / Current.

The **R** channel type returns the resistance value in ohms (Ω).

The *DT80* incorporates two precision current sources. When measuring a resistance, one or other of these sources is switched through to the ***** (Excite) terminal, which is then connected to the unknown resistance. (On Series 3 models, excitation can also be directed to the + or – terminals.)

By default, an accurately known current of approximately 200µA is generated by the *DT80*. This allows measurement of resistances up to about 10kΩ. For low resistances (up to 700Ω), the **II** channel option can be used to select a higher excitation current (2.5mA), which will allow a more accurate reading.

One problem which occurs when measuring low resistance values is the fact that the wires used to connect the unknown resistance to the logger also have resistance. As shown in the wiring diagrams below, there are various ways to overcome this. These involve the use of separate wires to carry the excitation current and to sense the voltage.

For example, the channel **1R(4W)** will perform a **four-wire** measurement. Excitation current flows out the ***** terminal, through the unknown R, and returns to the **#** terminal. Two separate **sense** wires connect the **+** and **–** terminals to the unknown R. Because the *DT80* has a very high input impedance (>10MΩ), negligible current will flow in these sense wires, resulting in a negligible voltage drop. The measured voltage will therefore be the voltage across the unknown R only, and will not include any voltage drop in the current-carrying excitation cables.

The downside of a four-wire measurement is that you need, well, four wires. The three and two wire configurations provide for reduced cable cost, at the expense of accuracy.

Channel Options

The following channel options are commonly used when measuring resistances:

- **3W** (3 wire; default), **4W** (4 wire) or **2W** (2 wire; Series 3 only) specifies the type of resistance measurement (number of wires)
- **I** (200µA excitation; default) or **II** (2.5mA excitation) specifies the amount of current to be passed through the resistance.
- the **channel factor** specifies an offset adjustment (ohms) which is subtracted from the measured value. This can be used to compensate for lead resistance in 2-wire configurations.
- **GL***x*, **ES***n*, as for voltage measurements

R1 – 4-Wire Resistance Inputs

In this configuration the * and # terminals send an excitation current through the unknown resistance while the remaining terminals sense the voltage across it.

4-wire resistance methods are the most accurate, especially for low resistances.

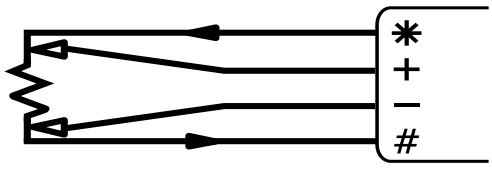


Figure 95: Wiring for 4-wire resistance input

To measure	Use the command
R	`1R(4W)`

R2 – 3-Wire Resistance Inputs

In this configuration the *DT80* effectively measures the voltage drop in the return lead and uses it to compensate for the voltage drop in both leads. This assumes that the excite and return lead resistances are equal.

See *3-Wire Compensation* (P299) for more details.

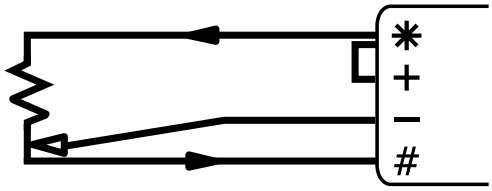


Figure 96: Wiring for 3-wire resistance input

To measure	Use the command
R	`1R`

R3 – 2-Wire Resistance Inputs

2-wire configurations are only recommended if the lead resistance is negligible compared to the resistance being measured.

You can, however, compensate for the lead resistance by inserting a resistor equal to the total lead resistance (excite lead resistance + return lead resistance) between the **–** and **#** terminals, in place of the link shown. This uses the *DT80*'s 3-wire compensation circuit to effectively subtract the measured voltage drop across the resistor from the reading.

Alternatively, the total lead resistance could be specified as the channel factor, e.g. if the total lead resistance is known to be 2.8 Ω then you would specify the channel as `1R(2.8)`. (This assumes that the lead resistance remains fixed, which may not be the case if the temperature varies.)

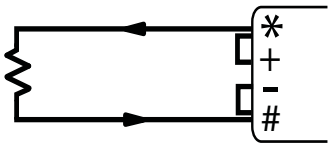


Figure 97: Wiring for 2-wire resistance input

To measure	Use the command
R	`1R`

R4 – 2-Wire Independent Resistance Inputs

Note This configuration is not available on DT80/81 Series 1 loggers.

A 2-wire measurement can also be made by connecting the resistance to * and # only. This frees up the + and – terminals for a separate independent measurement. For example, vibrating wire strain gauges often incorporate a thermistor temperature sensor. This wiring configuration would allow the gauge to be connected to + and – and the thermistor to * and #.

Note that no lead resistance compensation is possible with this configuration (other than by using the channel factor).

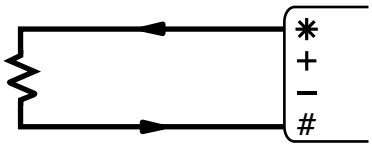


Figure 98: Wiring for 2-wire independent resistance input

To measure	Use the command
R	`1*R`

R5 – Series 3 2-Wire Resistance Inputs

Note These configurations are only available on Series 3 loggers.

Series 3 models can direct excitation to either the *, + or – terminal. This allows 2-wire resistance measurements to be made between the + and –, * and #, + and # or – and # terminals.

Use the `2W` channel option to select these types of measurements.

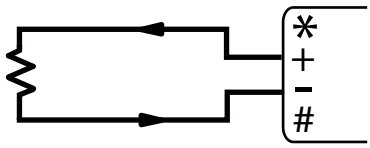


Figure 99: Wiring for 2-wire independent resistance input (Series 3 only)

To measure	Use the command
R	`1R(2W)`

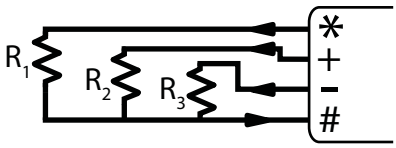


Figure 100: Wiring for 2-wire shared terminal resistance inputs (Series 3 only)

To measure	Use the command
R1	`1*R(2W)`
R2	`1+R(2W)`
R3	`1-R(2W)`

Note For these 2-wire configurations, the excitation is fixed at 200µA (`I`).

These measurements can be useful for detecting open circuit sensors. For example, the following will force an invalid reading to be logged if a vibrating wire strain gauge is detected as open circuit:

```
1FW(=1CV,W)
IF(1R(2W)>5000){1CV=99999}
1CV("freq")
```

R6 – High Resistance Input with Parallel Resistor

Resistance measurements are limited to a maximum of about 10kΩ. This can be extended by wiring a known resistor in parallel with the resistance being measured. This will, however, reduce the resolution of low resistance measurements.

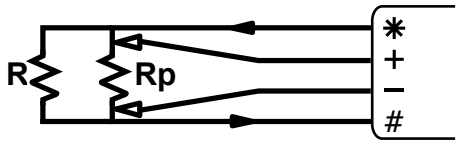


Figure 101: Wiring for 4-wire resistance input, using a parallel resistor

To measure	Use the command
R	`1R(4W,W)` `CALC("R~ohm")=(Rp*&1R)/(Rp-&1R)`

As shown above, we first read the combined resistance, then calculate the value of *R* using an expression that references the combined resistance measurement (`&1R`). *Rp* represents the value of the parallel resistor in ohms.

As well as the 4-wire configuration shown here, a parallel resistor can also be used with a 3-wire or 2-wire resistance measurement.

In all cases, the parallel resistor (*Rp*) should be located near the sensor (*R*), as shown above, so that the lead resistances can be correctly compensated for.

If it is not practical to locate the resistor near the sensor then it can be located at the logger end of the cable. In this configuration the best accuracy will be obtained by connecting the sense inputs (+ and -) across *Rp* (if its resistance is significantly less than *R*). If *Rp* is greater than *R* then the sense inputs should instead be connected across *R*, although in this case the effect of cable resistance is likely to be negligible, given that both *R* and *Rp* are high resistances.

Calculating Parallel Resistor Value

The required value of the parallel resistor *Rp* is given by:

$$R_p = \frac{10000 \times R_{max}}{R_{max} - 10000}$$

where R_{max} is the maximum resistance required to be measured.

For example, to measure up to 100 kΩ a parallel resistor of about 10kΩ would be suitable.

Bridges

Because of its sensitivity, the **Wheatstone bridge** circuit is commonly used for the measurement of small changes in electrical resistance. Applications include load cells, pressure sensors and strain gauges.

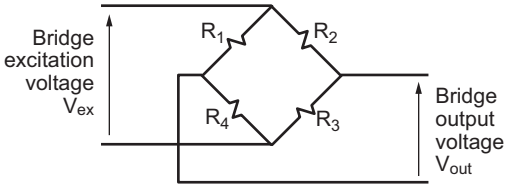


Figure 102: Wheatstone bridge

Bridges are designed such that under quiescent conditions the ratios R1/R4 and R2/R3 are equal, resulting in a zero output voltage, V_{out}. A small change to one or the resistances will then cause a corresponding change to V_{out}, which can then be measured accurately using the *DT80*'s sensitive 30mV range.

When one of the four resistors in a bridge is active (that is, sensitive to the quantity being measured) the circuit is called a **quarter bridge**, and the remaining three resistors are called **bridge completion resistors**. Similarly, **half** and **full** bridges imply two and four active gauges. All completion resistors should be close-tolerance precision resistors.

The *DT80* returns all bridge measurements in a ratiometric form with units of parts per million (ppm):

$$B_{out} = \frac{V_{out}}{V_{ex}} \cdot 10^6 \text{ ppm}$$

where:

- **V_{out}** is the measured bridge output voltage
- **V_{ex}** is the excitation voltage

For a bridge measurement to be accurate, both of these voltages must be known accurately, and any lead or connector resistances must be compensated for.

Channel Types

The *DT80* supports two bridge channel types, which differ by the way in which the excitation voltage V_{ex} is determined.

For a **BGV** channel, V_{ex} is measured at the bridge; for **BGI**, the bridge is excited using a known current and then V_{ex} is calculated from the known current and arm resistance values.

The **BGI** channel type supports two different wiring variants: a true bridge configuration and a 3-wire "simulated bridge" which has many of the properties of a bridge.

Channel Types	Description
BGV	Voltage-excited Wheatstone bridge
BGI (4W)	Current-excited Wheatstone bridge
BGI (3W)	Current-excited simulated bridge

For a voltage-excited bridge, two separate measurements are therefore required – one to measure V_{ex} and one to measure V_{out}. To provide the maximum flexibility in wiring, this is done using two separate channels (one **V**, one **BGV**), which are linked using the special **BR** channel option, as described below.

For a current-excited bridge, the nominal arm resistance is specified, and the *DT80* uses this, along with the known excitation current, to calculate V_{ex}.

Channel Options – BGV

The following channel options are applicable when using **BGV** channels

- the excitation options specify how the bridge is powered: **V** (use internal 4.5V voltage source; default), **E** (external supply connected to **EXT*** terminal) or **N** (external supply).
- **GL***x*, **ES***n*, as for voltage measurements
- the **channel factor** specifies an offset in ppm, which will be subtracted from the reading. This can be used to "zero" the output.
- the **BR** (bridge reference) option must be specified for the voltage (**V**) channel used to measure V_{ex}. This tells the *DT80* to use the measured voltage as V_{ex} for a subsequent **BGV** channel in the same schedule.

Channel Options – BGI

The following channel options are applicable when using **BGI** channels

- the excitation options specify how the bridge is excited: **II** (use 2.5mA precision current source; default) or **I** (use 200µA source).
- the wiring options specify the type of bridge: **3W** (simulated bridge; default) or **4W** (true bridge)
- the **channel factor** specifies the arm resistance, in ohms (default is 350. All arms are assumed to have equal nominal resistance.

The following sections describe the various bridge wiring configurations.

B1 – 6-Wire BGV Inputs

In this configuration the bridge excitation is supplied by an external supply. This power supply can be either:

- a standard supply, max 3V. This allows the *DT80* to measure the actual excitation voltage using the * and # terminals (**1*V**), as shown in the wiring diagram.
- a standard supply in the range 3-6V. This is too large to directly measure using the * and # terminals, so instead we use the bridge as a 2:1 voltage divider. That is, we measure the voltage between the + and # terminals (**1+V**), then scale the result by 2 to give the actual excitation voltage.
- a precision 5.00V supply. In this case the *DT80* does not measure V_{ex} – it assumes that it is exactly 5.00V. The power supply should be located close to the bridge to avoid voltage drop due to cable resistance.

Note Using the **HV** channel type to measure the bridge excitation voltage is not recommended. This channel type is normally not sufficiently accurate for bridge applications.

Assuming a non-precision power supply, two channel definitions will be required.

- The first (**1*V**) measures the voltage between the * and # terminals, and includes the **BR** (bridge reference) option which indicates that its value is to be used as the excitation voltage for subsequent bridge channels in the same schedule. It is also usually made a working channel (**W**) because it is merely an intermediate measurement.

  If a 3-6V supply is used then the appropriate channel definition would instead be **1+V(2,BR,W)** : measure between + and #, scale by 2 then use as bridge reference.

  If a 5.00V precision supply is used then this channel is not required.
- The second (**1BGV**) measures the bridge output voltage between the + and – terminals. The **N** (no excitation) channel option is specified because in this configuration the excitation is provided externally.

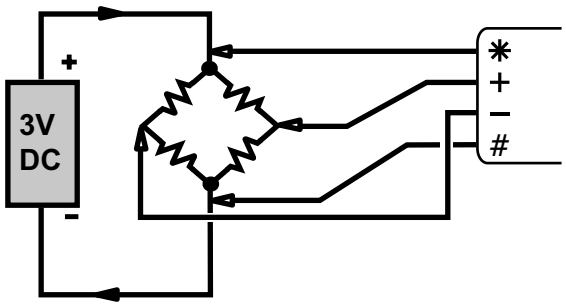


Figure 103: Wiring for 6-wire bridge using external voltage excitation

To measure	Use the command	
bridge output (3V supply)	**1*V(BR,W)**	**1BGV(N)**
bridge output (6V supply)	**1+V(2,BR,W)**	**1BGV(N)**
bridge output (5.00V supply)		**1BGV(N)**

B2 – 4-Wire BGV Inputs

This configuration is similar to the 6-wire configuration except that the bridge excitation is supplied by the *DT80*'s internal voltage source (approx 4.5V). This supply is in the range 3-6V, so it requires that the excitation be measured using the + rather than the * terminal then scaled by 2.

Note also that the **V** channel option must be specified to tell the *DT80* to switch on voltage excitation while the voltage measurement is being taken. This option is the default for the **BGV** channel, so it need not be specified.

This configuration is not recommended if the lead lengths are long, because the return wire is carrying the excitation current and we cannot compensate for the voltage drop over the length of the return wire. This will lead to an inaccurate excitation voltage measurement, and hence an inaccurate bridge measurement.

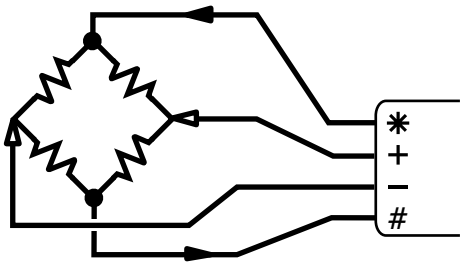


Figure 104: Wiring for 4 wire bridge input using internal excitation

To measure	Use the command
bridge output	`1+V(BR,2,V,W) 1BGV`

Note Using the **HV** channel type to measure the bridge excitation voltage is not recommended. This channel type is normally not sufficiently accurate for bridge applications.

B3 – Multiple BGV Half Bridge Inputs

In this configuration, three (or more) separate half bridges are wired in parallel so they share the same power supply and completion resistors (*Rc*). This allows three separate bridge measurements to be made per input channel (plus one channel to measure the excitation.)

The excitation voltage is measured in the same way as for the 6-wire configuration. That is, it is either

- measured directly, using * and # terminals, or
- measured using the completion resistors as a 2:1 voltage divider, or
- assumed to be 5.00V

Then the half bridge output voltages (relative to the junction between the completion resistors) are measured using separate analog inputs.

Note that the excitation voltage need only be measured once; it will then be used for all subsequent **BGV** channels in the same schedule.

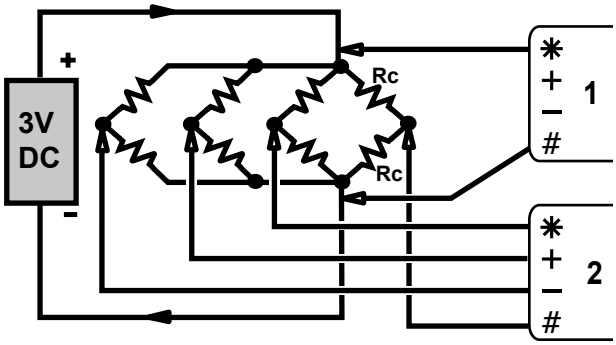


Figure 105: Wiring for multiple half bridges using shared external excitation

To measure	Use the command			
3 x bridge outputs (3V supply)	`1*V(BR,W)`	`2*BGV(N)`	`2+BGV(N)`	`2-BGV(N)`
3 x bridge outputs (6V supply) *Connect 1* to Rc junction*	`1*V(2,BR,W)`	`2*BGV(N)`	`2+BGV(N)`	`2-BGV(N)`
3 x bridge outputs (5.00V supply)		`2*BGV(N)`	`2+BGV(N)`	`2-BGV(N)`

B4 – 4-Wire BGI Inputs

A current excited bridge is the recommended configuration for 4 wire bridge measurement, especially for bridges that are distant from the *DT80*.

In this configuration the *DT80*'s precision current source provides the excitation. To calculate the excitation voltage, the *DT80* needs to know the arm resistance, R_a, which is specified as the channel factor. The default is 350 Ω.

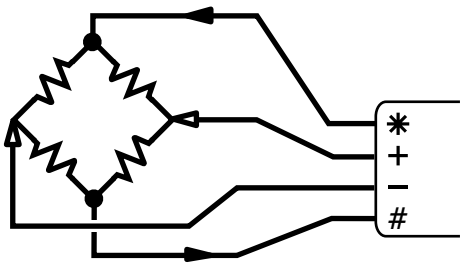


Figure 106: ***B2*** *Wiring for 4 wire bridge input using internal excitation*

To measure	Use the command
bridge output	`1BGI(4W,` R_a`)`

B5 – 3-Wire BGI Input

In this configuration *Rc* may be either an active gauge (if the strain on it is in the opposite direction to that on *Ra* and of the same magnitude) or a completion resistor. For temperature compensation, *Rc* can also be a gauge which has the same temperature characteristics as *Ra* but is not under any strain.

The resistances of *Rc* and *Ra* should be equal, and must be specified as the channel factor (max. 5kΩ, default is 350Ω).

This configuration simulates a bridge by using the *DT80*'s 3-wire compensation circuit to "compensate" for the voltage drop across *Rc*. The end result is that, like a bridge, the *DT80* measures the difference between the voltages across the two arms.

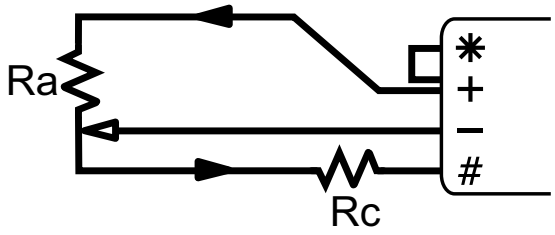


Figure 107: ***B3*** *Wiring for 3 wire bridge input using internal current excitation*

To measure	Use the command
bridge output	`1BGI(`R_a`)`

Temperature – Thermocouples

Thermocouple Theory

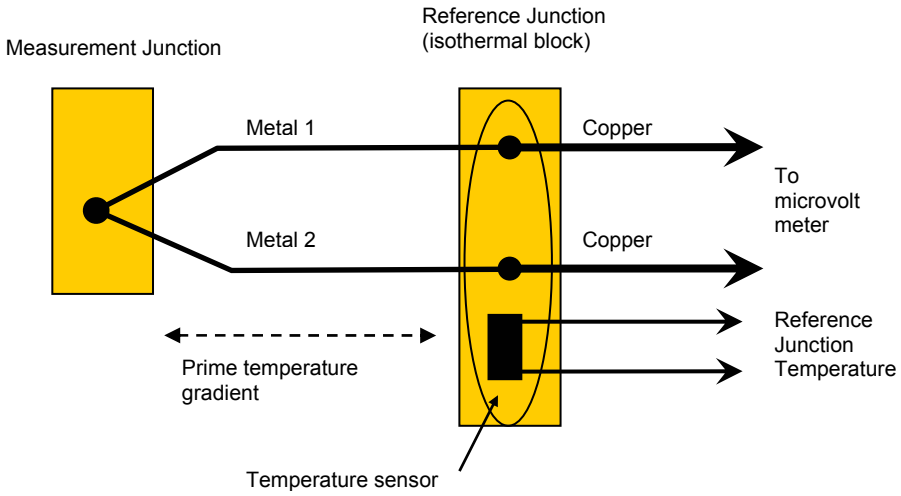


Figure 108: Thermocouple principle of operation

A thermocouple consists of two wires of dissimilar metals that are

- electrically connected at one end (the measurement junction) and
- thermally connected at the other end (the reference, or "cold" junction).
- A small voltage is produced when the two junctions are at different temperatures. (The voltage is produced by the temperature gradient along the wires, not by the junctions.)

Making The Measurement Junction

The measurement junction can be made by welding, brazing, soldering or crimping the two wires together. Take care to ensure that the wire material is not contaminated where the temperature gradient is to occur.

The junction can be insulated, or left bare for a more rapid response. If left bare, ensure that the junction does not make intermittent contact with metal objects. This can introduce electrical noise.

Sometimes thermocouple measurement junctions are electrically connected (by welding, brazing, soldering or by contact) to the object being measured. This is only possible if the object is grounded to the *DT80*'s analog ground terminal **AGND/EXT#**, or if the voltage on the object relative to the *DT80*'s analog ground is within the *DT80*'s common mode limits.

Reference Junction Compensation

Conventionally, the reference junction is held at 0°C, and thermocouple responses are determined with a 0°C reference. This is inconvenient in most situations and so, in practice, the reference junction is allowed to follow to ambient temperature. Then this non-zero reference junction temperature must be compensated for by measuring the reference temperature with another temperature sensor. The *DT80* does this compensation automatically when a thermocouple channel type is selected.

Isothermal Block

Generally the reference junctions and the associated temperature sensor are held at the same temperature by a physical arrangement that ensures good thermal conductivity between the junctions. This structure is called an "isothermal block". It is advisable to insulate the isothermal block from rapid ambient temperature changes.

Channel Types

The *DT80* supports all commonly-recognized thermocouple types:

Type	Positive	Negative	Range
B	Pt, 30%Rh	Pt, 6%Rh	+50 – +1820 °C
C	W, 5%Re	W, 26% Re	0 – +2320 °C
D	W, 3%Re	W, 25%Re	0 – +2320 °C
E	Ni, 10%Cr	Cu, 45%Ni	-270 – +1000 °C
G	W	W, 26% Re	0 – +2320 °C
J	Fe	Cu, 45% Ni	-210 – +1200 °C

K	Ni, 10%Cr	Ni,2%Mn, 2%Al	-270 – +1372 °C
N	Ni, 14%Cr, 1%Si	Ni, 4%Si, 0.1%Mg	-270 – +1300 °C
R	Pt, 13%Rh	Pt	-50 – +1768 °C
S	Pt, 10%Rh	Pt	-50 – +1768 °C
T	Cu	Cu, 45%Ni	-270 – +400 °C

Each type has characteristics (sensitivity, stability, temperature range, robustness and cost) that make it appropriate for particular applications.

The *DT80*'s thermocouple linearisation data are based on the ITS90 International Temperature Scale.

Channel Options

The applicable channel options for thermocouples are as follows

- **GL***x*, **ES***n*, as for voltage measurements
- the **channel factor** specifies a scaling factor, as for voltage channels
- If an external isothermal block is used then the **TR** (temperature reference) and/or **TZ** (electrical zero reference) options should be specified for the channels used to measure reference junction temperature and reference junction electrical zero. See *Isothermal Block Support* *(P247)* below.

Using Thermocouples with the DT80

Thermocouples are wired to the *DT80* as for any other voltage input, see *Voltage* *(P234)*. Be sure to connect the thermocouple the right way around – for K type thermocouples the red wire is normally negative and would therefore be wired to the # or – terminal.

The channel type is a **T***t* where *t* is the thermocouple type. So to measure a K-type thermocouple you would use the **TK** channel type, e.g. **4TK** for a thermocouple wired to channel 4's + and – terminals, or **4-TK** if the thermocouple is wired between – and #.

Using the thermocouple channel type reads the channel as a voltage and automatically applies reference junction compensation and linearization.

By default, the *DT80* uses an internal temperature sensor to measure the reference junction temperature. You can check the reading of this sensor using the **REFT** channel type.

Each CEM20 channel expansion module includes its own temperature sensor, which is used for any thermocouple measurements made using that CEM20. This sensor can be read using the *n***REFT** channel type, where *n* is the CEM number (1-15).

Isothermal Block Support

For higher accuracy measurements, the *DT80* also supports the use of an external **isothermal block**. In this case the isothermal block's temperature sensor is measured by a separate *DT80* channel. This channel uses the **TR** channel option to identify it as the temperature reference – its reading will then be used as the reference for all subsequent thermocouple measurements in that schedule.

For example:

```
RA10S 5AD590(TR) 1..4TT
```

In this example four T-type thermocouples are measured. Their reference junctions are enclosed in an isothermal block, along with an AD590 temperature sensor, which is connected to analog channel 5.

If the isothermal block is already compensated (i.e. it is held at 0°C) then it is not necessary to measure its temperature. Instead, use **11SV(TR)** as reference channel (system variable 11SV always returns 0.0).

To further enhance accuracy, you can use another *DT80* channel to measure the electrical "zero" at the isothermal block in order to compensate for any voltage offsets between the logger and the reference junctions. This is done by running a separate pair of wires (similar to those used for the thermocouple channels) from the *DT80* to the isothermal block, at which point they are shorted together. A voltage channel is then used to measure the offset voltage and the **TZ** channel option is specified. This will cause all subsequent thermocouple channels in the same schedule to use this value as their zero, rather then the *DT80*'s internal zero. For example:

```
RA10S 5AD590(TR) 6V(TZ) 1..4TT
```

Note If a **TR**/**TZ** channel is used, it must precede the thermocouple channel(s) to which it applies, and be in the same sampling schedule. If a statistical option (e.g. **AV**, **MX**) is applied to a thermocouple channel then the sampling schedule is the statistical schedule, so the reference channel must be sampled in the statistical schedule too. This can be achieved by applying a statistical option to the reference channel, e.g.

```
RS1S
RA1M 5PT385(TR,AV,W) 1..2TE(AV) 3TK
```

In this example, the PT385 will be read once a second, and will be used as the cold junction reference for the two subsequent TE thermocouple measurements. The average theremocouple readings will then be reported once a minute. The third thermocouple (3TK) is not sampled in the statistical schedule, and will use the default internal temperature reference.

Accuracy — Thermocouple Techniques

The accuracy of temperature measurement with thermocouples depends on

- the reference junction isothermal characteristics
- the reference temperature sensor accuracy
- induced electrical noise
- the quality of the thermocouple wire
- drift in the wire characteristics, especially at high temperatures
- the basic measurement accuracy of the *DT80*
- the linearization accuracy of the *DT80*.

Reference Junction Error

The most significant source of error is the reference junction. The *DT80* must not be exposed to non-uniform heating because a single reference temperature sensor is used to measure the temperature of the terminals of all channels. If a temperature gradient occurs along the terminals, errors of the magnitude of the temperature difference occur.

For the DT80/81, the reference temperature sensor is positioned behind analog channels 2 and 4, and behind channel 10 on the DT85. Therefore, when precise temperature measurements are required, attach thermocouples here for the least temperature differential from the *DT80*'s reference temperature.

Linearization Error

The *DT80*'s linearization errors are much lower (< 0.1°C over the full range) than other error sources.

Temperature – Thermistors

Thermistors are devices that change their electrical resistance with temperature. They measure temperatures from –80°C up to 250°C, and are sensitive but highly nonlinear.

Thermistors may be connected using any of the resistance wiring configurations, i.e. in 2-wire, 3-wire or 4-wire configuration. See *Resistance* (P239)

Channel Types

The *DT80* has channel types for many 2-wire YSI (Yellow Springs Instruments) thermistors and, for other thermistor types, the *DT80* supports thermistor scaling — see *Thermistor Scaling* (P61).

Channel Type	R (ohms) at 25°C	YSI Thermistor	Max. Temp °C	Min. Temp °C (without Rp)
YS01	100	44001A, 44101A	100	–75
YS02	300	44002A, 44102A	100	–50
YS03	1000	44003A, 44103A	100	–25
		44035	100	
YS04	2252	44004, 44104	150	–5
		44033	75	
		45004, 46004	200	
		46033, 46043		
		44901	90	
		44902	70	
YS05	3000	44005, 44105	150	0
		44030	75	
		45005, 46005	200	
		46030, 46040		
		44903	90	
		44904	70	
YS07	5000	44007, 44107	150	10
		44034	75	
		45007, 46007	250	
		46034, 46044		
		44905	90	
		44906	70	
YS17	6000	44017, 44117	150	15
		45017	250	
		46017	200	
		46037, 46047		
	10k	44016, 44116	150	25

YS16	10k	44016, 44116	150	25
		44036	75	
		46036	200	
YS06	10k	44006, 44106	150	25
		44031	75	
		45006	250	
		46006	200	
		46031, 46041		
		44907	90	
		44908	70	

Channel Options

The following channel options are useful with thermistors (**YS***nn* channel type):

- **3W**, **4W** can be used to select the wiring configuration, as with any resistance measurement
- **I**, **II** can be used to set the excitation. For thermistors the **I** (200µA) option should normally be used, to minimise any self-heating effects which may occur with higher excitation currents.
- the **channel factor** is the value of an optional parallel resistor, *Rp*, which can be used to extend the temperature range, as described below.

Reading Low Temperatures with Thermistors

Most thermistors increase in resistance as the measured temperature decreases (i.e. they have a negative temperature coefficient). They tend to be quite non linear and increase in resistance rapidly as the temperature falls into the lower part of the sensing range.

The *DT80* has an upper limit of 10kΩ for resistance measurement which can limit the usable sensing range of thermistors. To overcome this you can use a parallel resistor to scale the output of the thermistor back into the measurement range of the logger, as described in *R6 – High Resistance Input with Parallel Resistor* (P241)

For **YS***nn* thermistors, the value of the parallel resistor can be specified as the channel factor and the *DT80* will automatically scale the measured value appropriately. For example, a **YS06** thermistor has a resistance of approximately 80kΩ at –20°C, so to measure down to this temperature a parallel resistor of about 10kΩ would be suitable. You would then read the channel using

```
1YS06(10000)
```

i.e. the channel factor indicates that a 10000Ω parallel resistor is being used.

If a custom thermistor scaling function is being used then the correction will need to be done using channel variables or references, as described in *R6 – High Resistance Input with Parallel Resistor* (P241).

Temperature – RTDs

Resistance Temperature Detectors are sensors generally made from a pure (or lightly doped) metal whose electrical resistance increases with temperature. Provided that the element is not mechanically stressed and is not contaminated by impurities, the devices are stable, reliable and accurate.

Channel Types

The *DT80* supports four RTD types:

Channel Type	Metal	Default 0°C ohms	Alpha	Standard
PT385	Platinum	100	0.003850	DIN43760 (European)
PT392	Platinum	100	0.003916	JIS C1604 (American)
NI	Nickel	1000	0.005001	
CU	Copper	100	0.00390	

The alpha is defined by:

$$\alpha = \frac{R_{100} - R_0}{100 R_0} \quad \Omega/\Omega/°C$$

where R_o is the resistance at 0°C and R_{100} is the resistance at 100°C.

The 0°C resistance is assumed to be 100Ω for platinum (PT100), and 1000Ω for nickel types. Other values can be specified as a channel option.

Channel Options

The following channel options are useful with RTD channel types:

- **3W**, **4W** can be used to select the wiring configuration, as with any resistance measurement
- **I**, **II** can be used to set the excitation. For the Platinum and Copper RTDs, the **II** (2.5mA) option (which is the default) should normally be used, to provide good measurement resolution for the relatively low resistance value being

measured. If self-heating is a concern, the **I** (200µA) excitation option can also be used. For the higher resistance Nickel type, **I** (200µA) is the default.

- the **channel factor** is the 0°C value of the RTD, e.g. 100 for a PT100 sensor. The default value for each type is shown in the table above.

For example,

```
PT385(4W,50)
```

reads a 4-wire 50Ω (at 0°C) device.

Temperature – AD590 Series IC Sensors

AD590 series sensors are 2-terminal semiconductor devices which produce a current that is proportional to absolute temperature. This makes them useful with long lead lengths. Supply voltage is typically 4-30V.

Channel Types

The following channel types are supported. All operate identically.

Channel Type	Description	Range
AD590	1µA / K	-55 – +105 °C
AD592	1µA / K	-25 – +105 °C
TMP17	1µA / K	-40 – +105 °C

Channel Options

The following channel options are sometimes used when measuring AD590 series devices:

- the excitation options specify how the sensor is powered: **V** (use internal 4.5V voltage source; default), **E** (external supply connected to **EXT*** terminal) or **N** (external supply).
- **MD***n* (measurement delay) specifies that the *DT80* should wait *n* ms (default 10ms) after selecting a channel before starting the actual measurement. This can be useful in conjunction with the **E** or **V** option, as it allows the sensor some time to stabilise after power is applied to it.
- the **channel factor** specifies the shunt resistance in ohms (default 100.0 Ω), as for current measurements
- **GL***x*, **ES***n*, as for voltage measurements

Calibration

The channel factor (shunt resistor value) can also be used as a calibration factor. For example, if the sensor reads 290.7K when the actual temperature is 289.5K (an error of +1.2K) then the required scaling factor would be 1 – (1.2 / 289.5) = 0.9959, which would then be multiplied by the nominal shunt resistance (100). So the correction would be applied as:

```
1AD590(99.59)
```

Note that if the *DT80*'s internal shunt is used (e.g. **1#AD590**), then you need to specify the shunt resistor's nominal resistance as the channel factor when doing the calibration measurement, i.e. **1#AD590(100)** . If this is not done then the *DT80* will use the actual shunt resistance (which it determines during its self calibration process), which will upset the above calculation because you won't know what to multiply the scaling factor by.

IC1 – 2-Wire AD590-Series Inputs

The wiring configuration shown below uses the *DT80*'s internal voltage excitation to power the sensor, and the internal shunt resistor to measure the output current.

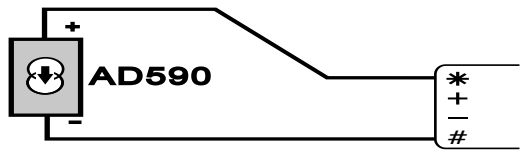


Figure 109: Wiring for AD590 series input using internal shunt

To measure	Use the command
temperature	**1#AD590**

Other Wiring Options

External shunts and/or external power supplies (as per the wiring configurations for current) can also be used to allow more sensors to be measured per channel.

For example, the configuration shown in *C1 – Shared-Terminal Current Inputs with External Shunts* *(P237)* could be used to allow three AD590s to be measured on the one channel. Note that in this case the **N** channel option would be required, in order to disable the default voltage excitation output on the * terminal, i.e.

To measure temperature	Use the command
I1	`1*AD590(N,R1)`
I2	`1+AD590(N,R2)`
I3	`1-AD590(N,R3)`

Alternatively, separately connected shunts could be used, as shown in *C2 – Independent Current Inputs with External Shunts* (P238). That is:

To measure temperature	Use the command
I1	`1AD590(N,R1)`
I2	`1*AD590(N,R2)`

Temperature – LM35 Series IC Sensors

LM35 series sensors are 3-terminal semiconductor devices which produce a voltage output that is proportional to temperature. Supply voltage is typically 4-30V.

Channel Types

The following channel types are supported:

Channel Types	Description	Range
LM34	10mV/°F	-50 – +300 °F
LM35	10mV/°C	-55 – +150 °C
LM45	10mV/°C	-20 – +100 °C
LM50	10mV/°C + 500mV	-40 – +125 °C
LM60	6.25mV/°C + 424mV	-40 – +125 °C
TMP35	10mV/°C	-40 – +125 °C
TMP36	10mV/°C + 500mV	-40 – +125 °C
TMP37	20mV/°C	-40 – +125 °C

The devices with a voltage offset (**LM50**, **LM60** and **TMP36**) allow negative temperatures to be read without additional components.

Channel Options

The following channel options are sometimes used when measuring LM35 series devices:

- the excitation options specify how the sensor is powered: **V** (use internal 4.5V voltage source; default), **E** (external supply connected to **EXT*** terminal) or **N** (external supply).
- **MD***n* (measurement delay) specifies that the *DT80* should wait *n* ms (default 10ms) after selecting a channel before starting the actual measurement. This can be useful in conjunction with the **E** or **V** option, as it allows the sensor some time to stabilise after power is applied to it.
- the **channel factor** specifies an offset adjustment, in °C
- **GL***x*, **ES***n*, as for voltage measurements

Calibration

For LM35 series sensors, the channel factor is an offset correction, in °C. So if the sensor reads 25.4°C when the actual temperature is 25.0°C (an error of +0.4°C) then the channel factor would simply be specified as:

```
4+LM35(0.4)
```

IC2 – LM35-Series Inputs

In this wiring configuration the sensor is powered by the *DT80*'s 4.5V voltage excitation. This single-ended supply means that the sensor's output voltage will not be able to go below about 100mV. For devices with no offset voltage (e.g. LM35) this restricts the minimum usable temperature to 10°C (for LM35).

Accuracy can be improved by replacing the link wire between the **#** and **–** terminals with a wire from the **–** terminal of the logger to the **–** terminal of the sensor. This will compensate for voltage drops due to cable resistance, similar to a 4-wire resistance measurement.

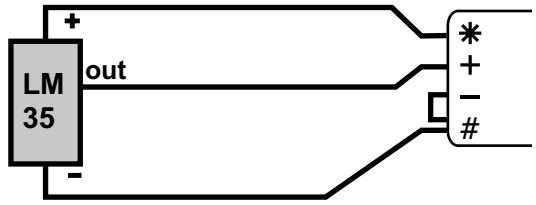


*Figure 110: **L2** Wiring for LM35 series input – restricted temperature range*

To measure	Use the command
temperature	**1LM35**

IC3 – LM35-Series Inputs – full temperature range

This wiring configuration biases the negative terminal of the device to allow negative temperatures to be read. Refer to the manufacturer's data sheet for more details.

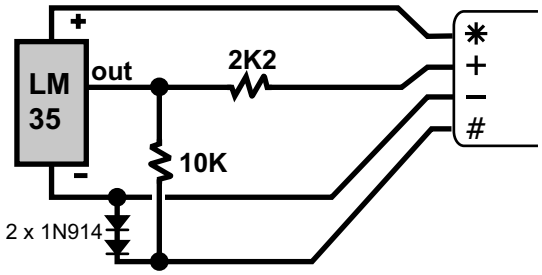


Figure 111: Wiring for LM35 series input – full temperature range

To measure	Use the command
temperature	**1LM35**

Other Wiring Options

Shared input configurations and/or external power supplies (as per the wiring configurations for Voltage) can also be used to allow more sensors to be measured per channel.

For example, the configuration shown in *V1 – Shared-Terminal Voltage Inputs* *(P236)* could be used to allow three externally powered LM35s to be measured on the one channel. That is, an external 4-30V dc supply powers the three sensors' + and – terminals, with the – terminals also connected to the *DT80*'s # terminal. The three *out* terminals would then connect to the *DT80*'s *, + and – terminals. These sensors could then be read using **1*LM35(N)**, **1+LM35(N)** and **1-LM35(N)** respectively. Note that in this case the **N** channel option is required in order to disable the default voltage excitation output on the * terminal.

Temperature – LM135 Series IC Sensors

LM135 series sensors are 2-terminal zener diode based sensors which produce a voltage output that is proportional to absolute temperature. Operating current is typically 0.5 – 5mA.

Channel Types

The following channel types are supported:

Channel Types	Description	Range
LM135	10mV / K	-55 – +150 °C
LM235	10mV / K	-40 – +125 °C
LM335	10mV / K	-40 – +100 °C

Channel Options

The following channel options are sometimes used when measuring LM35 series devices:

- the excitation options specify how the sensor is powered: **V** (use internal 4.5V voltage source; default), **E** (external supply connected to **EXT*** terminal) or **N** (external supply).
- **MD***n* (measurement delay) specifies that the *DT80* should wait *n* ms (default 10ms) after selecting a channel before starting the actual measurement. This can be useful in conjunction with the **E** or **V** option, as it allows the sensor some time to stabilise after power is applied to it.
- **GL***x*, **ES***n*, as for voltage measurements
- the **channel factor** specifies a scaling factor.

Note A 2:1 voltage divider is normally used to ensure that the output of the sensor stays within the *DT80*'s 3V input range. The default channel factor is therefore 2.0 for these channel types. If a different voltage divider ratio is used then an appropriate channel factor must be specified, e.g. if there is no divider then specify **1LM335(1)**.

Calibration

For LM135 series sensors, the channel factor is a scaling factor, which can be used to correct a slope error based on a single point calibration. For example, suppose an LM135 is connected using a 2:1 voltage divider as shown in the wiring diagram. If the channel then reads 301.0K when the actual temperature is 302.4K (an error of -1.4K) then the required scaling factor would be 2 – (–1.4 / 302.4) = 2.0046, which would be applied as:

```
2LM135(2.0046)
```

Most LM135 series devices also provide an ADJ pin which allows the connection of an optional external trimpot.

IC4 – 4-Wire LM135-Series Inputs

In this wiring configuration the *DT80*'s 4.5V voltage excitation is used to power the sensor (via an internal current limiting resistor). The output voltage then feeds a 2:1 voltage divider and is measured using the *DT80*'s + and – inputs.

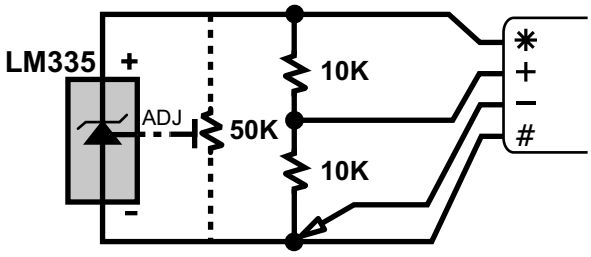


Figure 112: Wiring for LM135 series input

To measure	Use the command
temperature	**1LM335**

Humidity Sensors

Relative humidity is commonly measured by the "wet bulb depression" method. Two temperature sensors are required, one to measure air temperature and the other the cooling effect of a wetted surface. Usually a temperature sensor is encased in a wick extending into a reservoir of distilled water. The temperature difference between the two sensors is the wet bulb depression.

The choice of temperature sensors is critical if reasonable accuracy is required at high relative humidity where the wet bulb depression is small. If platinum RTDs are used they should have good accuracy or matching (0.2°C).

Good accuracy can also be achieved by use of a temperature difference sensor such as a thermocouple or thermopile. Measure the dry bulb with a standard grade temperature sensor and subtract the difference sensor reading to obtain the wet bulb temperature.

The sensors are normally placed within a radiation screen to prevent radiant heat affecting the readings. This is particularly important for outdoor applications.

Example — Humidity Measurement

The following program reads two RTDs and calculates the relative humidity with an accuracy of a few percent for temperature above 5°C and over most of the relative humidity range (the algorithm assumes that the sensors are ventilated but not aspirated).

```
BEGIN"STICKY"
Y1=6.1,0.44,0.014,2.71E-4,2.73E-6,2.75E-8 'SVP polynomial
RA5S
 1PT385("Dry bulb",4W)
 2PT385("Wet bulb",4W)
 3CV(Y1,W)=&"Dry bulb"
 4CV(Y1,W)=&"Wet bulb"
 5CV("RH%",FF1)=(4CV-0.8*(1CV-2CV))/3CV
END
```

Frequency

The frequency of an analog input signal can be measured using the **F** channel type, which returns a value in Hz.

Any of the *Voltage* wiring configurations may be used *(P234)*.

Note that the default threshold point is 0V, so the input signal must have zero crossings in order to be measured. If this is not the case (e.g. for a logic signal), the **2V** channel option can be used to change the threshold point to +2.5V.

Channel Options

Useful channel options for **F** channels are:

- the **channel factor** – this is the sample period (gate time) in ms (default is 30ms)
- **2V** – this option will offset input signal by -2.5V. This effectively changes the threshold point from 0V to approx. +2.5V, which is useful for TTL level inputs
- **GL***x*, **ES***n*, as for voltage measurements

Note For DT80/81 Series 1 loggers, the **2V** channel option is not supported for differential measurements (measurements between the + and – terminals, e.g. **1F**)

Note For frequency measurements, the maximum gain range (30mV full scale) is not available. The **GL30MV** option is therefore not valid for this channel type.

The range of frequencies that can be measured depends on the configured sample period (channel factor). For the default setting of 30ms, this range is approximately 33Hz – 20kHz. If the input frequency is too low to be measured, `UnderRange` will be returned.

To measure lower frequencies, the sample period should be increased. For example

```
3F(1000)
```

will measure down to 1Hz (upper limit is still 20kHz), while

```
3F(10000)
```

will allow frequencies down to 0.1Hz to be resolved.

The drawback to selecting a long sample period is that the measurement will take a long time to complete. This may delay the execution of other schedules.

Period Measurement

The period of a signal can be measured by taking the reciprocal of a frequency measurement, e.g.:

```
RA5S 3+F(2V,1000,F1,"Period~s",FF4)
```

will return the period, in seconds, of an TTL-level logic signal connected between **3+** and **3#**. Given the 1000ms sample period, the maximum period that can be returned will be approximately 1.0s. The **F1** option applies intrinsic function #1 (1/x).

Strain Gauges – Bridge

Bridge Wiring Configurations

Strain gauges change resistance when stretched or compressed. They are commonly wired in a **bridge** configuration, because bridges are well suited to measuring small changes in resistance; see *Bridges* *(P242)*.

Each of the arms of the bridge can be either:

- an active element: a strain gauge which is subjected to the forces acting on the structure
- a temperature compensation element: a strain gauge which is not stressed but which has similar temperature coefficient to the active gauge. This is used to cancel out any changes to the active gauge's resistance due to temperature effects.
- a completion resistor: a precision resistor whose resistance is equal to the nominal (at rest) strain gauge resistance.

A **full bridge** has four active gauges, typically two on one side of a structure (in tension) and two on the other (in compression). A **half bridge** has two active gauges; the other two arms are temperature compensation gauges or completion resistors. Finally a **quarter bridge** has only one active gauge.

Calculating Strain

The strain-to-resistance relationship is

$$strain = \frac{\Delta L}{L} = \frac{1}{G} \cdot \frac{\Delta R}{R}$$

where:

- ***L*** is the original length
- ***ΔL*** is the length change
- ***R*** is the original gauge resistance
- ***ΔR*** is the gauge resistance change
- ***G*** is the gauge factor, a measure of the sensitivity of the gauge (typical foil gauges have a gauge factor of 2.0, which means that if they are stretched by 1% their resistance changes by 2%)

Strain is a dimensionless quantity, as it is a ratio of length to length. Strain is often expressed in ppm form (i.e. the length ratio is multiplied by 1,000,000), in which case it has the units of **µStrain** (microstrain).

To convert the *DT80*'s ppm bridge readings to strain, use the formula:

$$strain = \frac{4}{G \cdot N} B_{out} \quad \mu\text{Strain}$$

where

- ***B*$_{out}$** is the *DT80*'s bridge channel (**BGV** or **BGI**) result (ppm)
- ***G*** is the gauge factor
- ***N*** is the number of active gauges in the bridge

The conversion can be done in the *DT80* by applying a polynomial as a channel option (see *Polynomials* (P61)):

```
Y1=0,k"uStrain"   ' Polynomial definition
3BGV(Y1)          ' Bridge channel
```

where *k* = 4 / GN

For the 3-wire BGI "simulated bridge" configuration (see *B5 – 3-Wire BGI Input* (P245)) the formula to convert ppm reading to strain is slightly different:

$$strain = \frac{2}{G \cdot N} B_{out} \quad \mu\text{Strain}$$

Strain Gauges – Vibrating Wire

DT80G/85G GeoLogger only

Vibrating wire strain gauges (VWSGs) are widely used for measuring strain in geotechnical applications. A gauge consists of a tensioned steel wire whose resonant frequency changes as deflections causes the wire's tension to change.

The DT80G/85G GeoLoggers include special hardware to support VW gauges. This works by generating a short electrical pulse to "pluck" the gauge, then measuring the resulting frequency as it resonates. The strain experienced by the gauge is proportional to the square of the resonant frequency minus the square of the "at rest" resonant frequency.

The **FW** channel type is used to measure the frequency of a VWSG. This operates in a similar way to the regular frequency channel type (**F**), except that the defaults for some options are different.

Channel Options

The following channel options are relevant for the **FW** channel type:

- the **channel factor** – this is the sample period (gate time) in ms (default is 200ms)
- **MD** (measurement delay) is important, as described below (default is 350ms)

Note that channel options relating to the *DT80*'s instrumentation amplifier, e.g. **GL***x* (gain lock) and **A** (attenuators), are not relevant for **FW** channels because much of the normal input circuitry is bypassed when performing a VWSG measurement.

VS1 – Vibrating Wire Strain Gauge and Thermistor

VW gauges can be connected to the *DT80* as for any other voltage input. For example, up to three gauges could be connected to one channel using the configuration shown in *V1 – Shared-Terminal Voltage Inputs* (P236)

Often the gauge will include an integral thermistor, to allow temperature corrections to be made. In this case it is often convenient to read both the thermistor and the gauge using a single *DT80* analog channel, as shown below.

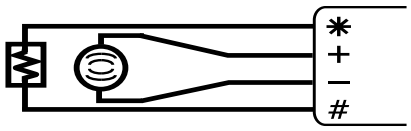


Figure 113: Wiring for vibrating wire strain gauge with thermistor

To measure	Use the command
strain	**1FW**
temperature	**1*YS01** (for example)

Measurement Timing

When an **FW** channel is evaluated, the measurement process is as follows:

1. The pluck circuit begins charging. The **MD** timer starts here also.
2. After about 100ms, the pluck circuit releases its energy in the form of a narrow high voltage pulse. Inside the sensor this causes the wire to start vibrating. The resonant frequency will typically be in the range 500-5000Hz.
3. Once the pluck is complete (about 0.2ms), the *DT80* disconnects the pluck circuit and begins listening to the sensor. Inside the sensor the wire's vibrations are sensed and a corresponding electrical signal is generated.

4. Over the next 100-200ms the *DT80*'s phase locked loop (PLL) locks on to the fundamental frequency and filters out noise and harmonics. During this time the amplitude of the signal gradually decays as wire's vibrations decay.
5. Once the **MD** timer expires the *DT80* will begin measuring the frequency of the filtered signal.
6. Once the required sample period (gate time) has elapsed, the *DT80* reports the measured frequency value.

It is important that the measurement delay is set such that the incoming signal is stable and of adequate amplitude for the duration of the measurement period. The default value is suitable for most gauges, but in some cases it may need adjustment, as discussed in *Measurement Delay and Sample Period* *(P256)*.

Troubleshooting

Listening to the Gauge

The DT80G/85G GeoLoggers provide a headphone output socket which can be useful in diagnosing problems, given that the sensor's vibration falls within the audible frequency range (500-5000Hz).

To check a gauge, connect headphones or speakers, then enter the following:

P21=1	this keeps the *DT80*'s analog section powered after the end of the measurement
P62=1	this maintains the multiplexer settings after the end of the measurement
1FW	this samples the VWSG connected to, in this case, channel 1 + and – terminals.

Each time you send the **FW** command you should hear a clear "ping" sound which decays over a period of a few seconds. If not:

- If there is no sound or only random noise, double check that you entered the correct channel number. Check all connections. Check the resistance of the gauge by connecting it to the * and # terminals then entering **1*R** several times. These 2-wire resistance measurements should return stable values. If not then a cable or gauge fault is indicated.
- If a ping can be heard but it is faint or buried in random noise, then the cable is too long or is "leaky", or the gauge sensitivity is too low.
- If the ping is not clean and pure, then the gauge is possibly faulty. The gauge may have been mechanically damaged during installation.
- If you can hear a low frequency hum, then noise pick is a problem. If the gauge is placed near a transformer, electric motor, high current power cables, etc, then relocate or reorient the gauge for minimum pickup. Ensure that the cable is shielded to prevent capacitive pickup. (Connect the shield to DGND or the *DT80* chassis earth point.)

Be sure to reset the P21 and P62 settings when finished.

Measurement Delay and Sample Period

If a strong and clear signal is heard, but the frequency measurements are unstable (variations of 10-20Hz or more) then there may be strong harmonics present in the gauge's vibration. Because harmonics usually decay faster than the fundamental, it will often help to increase the **MD** setting. This will mean that the actual frequency measurement phase starts later, at which point the amplitude of the harmonics should be less. If the measurement delay is increased too much, however, the overall signal amplitude may decay below the noise level.

If the signal is clear but decays rapidly then the default **MD** setting may in fact be too long – by the time the measurement completes the signal has decayed to nothing.

Some trial and error may be required to find optimal settings. The recommended procedure is as follows. For each step perform several measurements in order to gauge the stability of the readings.

1. Start with minimum values for measurement delay and sample period, e.g. **1FW(MD150,30)**
2. Increase the **MD** setting in, say, 20ms steps until stable readings are obtained, then go one step further.
3. Further improvement can usually be obtained by progressively increasing the sample period so that the frequency is measured over a longer time interval. If this is increased too far however then the signal amplitude will descend into the nose and readings will get rapidly worse.

Converting Frequency to Strain

As mentioned above, the strain experienced by a VWSG is proportional to the change in the square of the resonant frequency. That is:

$$strain = G\left(f^2 - {f_0}^2\right)$$

where:

- ***G*** is the gauge factor (supplied by the manufacturer)
- ***f*** is the measured frequency
- f_0 is the zero or "at rest" frequency

It is therefore necessary to take a zero reading, after installation of the gauge. This value should be recorded; it can then be used in a *DT80* program in order to return strain, e.g.

```
BEGIN
RA1M
 1FW("freq",W)                    read the frequency
```

```
 CALC("strain")=G*(&freq^2-f0^2)    calculate the strain, given gauge factor G and zero frequency f0
END
```

Temperature Correction

As the temperature of the VWSG changes, the steel wire will expand or contract. Its change in length is proportional to the change in temperature. A temperature change will therefore cause an addition or reduction to the measured strain. That is:

$$strain = G\left(f^2 - f_0^{\,2}\right) + C\left(T - T_0\right)$$

where:

- ***C*** is the temperature correction factor (supplied by the manufacturer; this is basically the coefficient of thermal expansion for the grade of steel used for the wire)
- ***T*** is the current temperature
- T_0 is the temperature at which the zero frequency measurement was taken

So if the gauge incorporates a **YS04** thermistor and is wired as per *VS1 – Vibrating Wire Strain Gauge and Thermistor* *(P255)* then a typical program might be:

```
BEGIN
RA1M
 1FW("freq",W)                          read the frequency
 1*YS04("temp")                         read the temperature
 CALC("strain")=G*(&freq^2-f0^2)+C*(&temp-T0)   calculate the strain and apply temperature correction
END
```

Strain Gauges – Carlson Meter

A Carlson meter consists of two tensioned steel wires (connected in series) whose resistance changes as they are strained. The wires are arranged so that a given strain causes the resistance of one wire to increase and the other to decrease. The strain is then proportional to the ratio of the two resistances.

The resistance labelled R1 in the wiring diagrams is the **expansion** wire (its resistance increases as the gauge is stretched), while R2 is the **compression** wire (its resistance increases as the gauge is compressed). Thus when the gauge is stretched, the ratio R1/R2 will increase, resulting in a positive strain reading. Conversely, compression will cause a decrease in ratio R1/R2 and a negative strain reading.

The wire resistances are also temperature dependent. The temperature is proportional to the total resistance, i.e. the sum of the two resistances.

A Carlson stress meter uses the same principle as a strain meter but is designed to indicate **stress** (force per unit area, unit MPa) rather than **strain** (displacement). Stress and strain proportional to each other according to the modulus of elasticity of the material.

Carlson meters are supplied in 3, 4, 5 or 6 wire configurations. The extra wires allow the logger to properly compensate for the cable resistance, which is often an important issue given that meters typically have a total resistance in the range 50-100Ω. Standard wire colours are normally (although not universally) used, as shown in the wiring diagrams.

Due to their low resistance, Carlson meters should normally be measured using the high (2.5mA) excitation setting (**II** channel option).

CS1 – 5 Wire Carlson Meter

The 5-wire configuration allows the *DT80* to perform a 4-wire measurement on each resistance. It can therefore fully compensate for cable resistance, including unequal cable resistances. It does, however, require two analog input channels per sensor.

Sometimes a sixth wire is included – an additional sense wire connected to the junction between the resistors. This can either be ignored or it can be connected to the + input of channel 2 in place of the link shown.

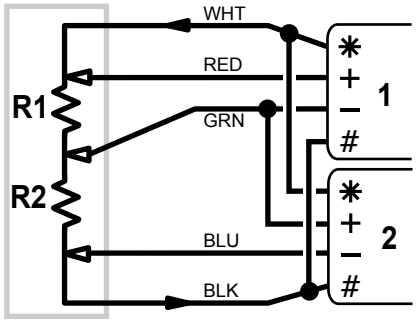


Figure 114: Wiring for 5-wire Carlson Sensor

To measure	Use the command
R1	`1R(4W,II)`
R2	`2R(4W,II)`

CS2 – 4 Wire Carlson Sensor

With a 4-wire configuration, the *DT80* is able to compensate for cable resistance, provided that the resistance is equal for all four wires. This is achieved by taking three separate resistance measurements (M1, M2 and M3) which include R1, R2 and the cable resistance (Rc) in various combinations.

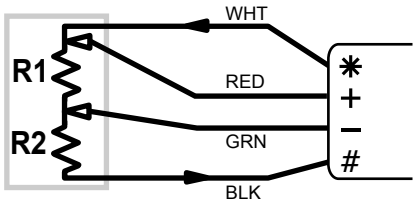


Figure 115: Wiring for 4-wire Carlson Sensor

To measure	Use the command
M1 (R1 + R2 + 2Rc)	`1*R(II)`
M2 (R1)	`1R(4W,II)`
M3 (R1 + R2 + Rc)	`1+R(II)`

Using these three measurements and a little algebra we can eliminate Rc and calculate the actual resistance values:

$$R_1 = M_2$$

$$R_2 = 2M_3 - M_1 - M_2$$

For example, the following *DT80* program will calculate the required resistances:

```
BEGIN
RA1M
 1*R("M1",II,W)
 1R("M2",4W,II,W)
 1+R("M3",II,W)
 CALC("R1~Ohm")=&M2
 CALC("R2~Ohm")=2*&M3-&M1-&M2
END
```

CS3 – 3 Wire Carlson Sensor

With this configuration the *DT80* is not able to take three independent measurements, so automatic lead resistance compensation is not possible.

This configuration will therefore require manual correction for cable resistance (*Rc*). This can be applied as the channel factor (which, for resistance, is an offset adjustment in ohms). The *Rc* value may be supplied by the manufacturer, or it can be measured manually (at a typical working temperature).

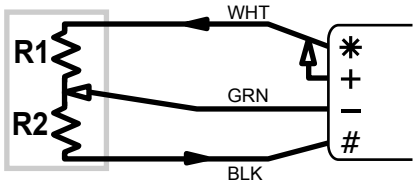


Figure 116: Wiring for 3-wire Carlson Sensor

To measure	Use the command
R1	**1R(4W,II,*Rc*)**
R2	**1-R(II,*Rc*)**

Calculating Temperature and Strain

Temperature

The temperature is given by:

$$T = \left(\left(R_1 + R_2\right) - b\right)a$$

where:

- ***T*** is the temperature (°C)
- ***R₁*** and ***R₂*** are the measured resistance values (Ω)
- ***b*** is the temperature offset: total resistance at 0°C (Ω) (supplied by manufacturer)
- ***a*** is the temperature factor: change in temperature per unit change in total resistance (°C/ Ω) (supplied by manufacturer). In some cases different factors may be supplied for different temperature ranges, e.g. one for above 0°C and one for below.

This temperature can then be used to correct the stress or strain calculation.

Strain and Stress

In general terms, strain (or stress) is proportional to the change in the ratio R1/R2 relative to some base value, less a correction for expansion due to temperature.

The precise form of the equation for calculating stress/strain will depend on the application and the actual data supplied by the Carlson meter manufacturer. The formula will normally be similar to:

$$strain = G\left(\frac{R_1}{R_2} - Z\right) - CT$$

where:

- ***G*** is the calibration factor: change in indicated strain per unit change in resistance ratio (supplied by manufacturer). This constant is typically specified as με/0.01%, i.e. microstrain per 0.01% ratio change. For a stress meter the calibration factor units will be different, e.g. kPa/0.01%.
- ***R₁*** and ***R₂*** are the measured resistance values
- ***Z*** is the "zero" resistance ratio. A value of "R1/R2 at 0°C" may be supplied by manufacturer, or an initial measurement of R1/R2 can be made soon after installation, which will form the zero point for subsequent strain values.
- ***C*** is the temperature correction factor: change in indicated strain per unit change in temperature (may be supplied by manufacturer) This constant is typically specified as με/°C, i.e. microstrain per °C.
- ***T*** is the temperature, as calculated above.

Example

The following example shows how the *DT80* might be used to calculate a strain value. It will most likely need to be adapted to suit the type of sensor and the application. In this case a 5-wire sensor is used, with the manufacturer supplied parameters as shown.

```
BEGIN
' Manufacturer data
' b = 68.22 ohm
' a = 4.86 degC/ohm
' G = 5.8962 ue/0.01%
' Z = 1.0137
' C = 10.56 ue/degC
RA12H
 1R(ES5,4W)                    measure R1, take 5 extra samples to reduce noise
 2R(ES5,4W)                    measure R2, take 5 extra samples to reduce noise
 CALC("Temp~degC")=((&1R+&2R)-68.22)*4.86          calculate temperature if required
 CALC("Strain~ue")=58962*(&1R/&2R-1.0137)-10.56*Temp     calculate strain
END
```

So in this case if the measured resistances were R1=36.44 and R2=35.56 then the calculated temperature would be 18.4°C and the strain +457 με.

Analog Logic State Inputs

For reading logic states, the *DT80*'s digital inputs (see *Digital Channels* *(P261)*) are the best option. If there are insufficient digital inputs then the analog inputs can also function as digital inputs, using the **AS** channel type.

The **AS** channel type detects an input voltage relative to a threshold:

- When the input is above the threshold, **1** is returned.
- When the input is below the threshold, **0** is returned.

Any of the *Voltage* wiring configurations may be used.

The default threshold is 2500mV, but the channel factor can be used to set any value in mV.

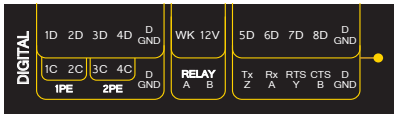
Input attenuators are enabled by default for the **AS** channel type, allowing input voltages up to 30V.

For example:

```
1AS(1750)
```

configures analog channel **1** as an analog state input with a threshold of 1.75V.

Digital Channels



The *DT80* provides:

- 4 bidirectional digital I/O channels (**1D**-**4D**) with open drain output driver and pull-up resistor (3 channels **1D-3D** for DT81/82E);
- 4 bidirectional digital I/O channels (**5D**-**8D**) with tri-stateable output driver and weak pull-down resistor (SDI-12 compatible) (1 channel **4D** for DT81/82E, none for DT82I);
- 1 voltage free latching relay contact output (**RELAY**)
- 1 LED output (**Attn**)
- 4 hardware counter inputs (**1C**-**4C**) which can be used as independent counter channels or as two quadrature (phase encoder) inputs (one only phase encoder input on DT81). Channels 1C and 2C are low threshold capable.

For detailed specifications, see *Digital Inputs and Outputs* (P307).

About the Digital I/O Channels

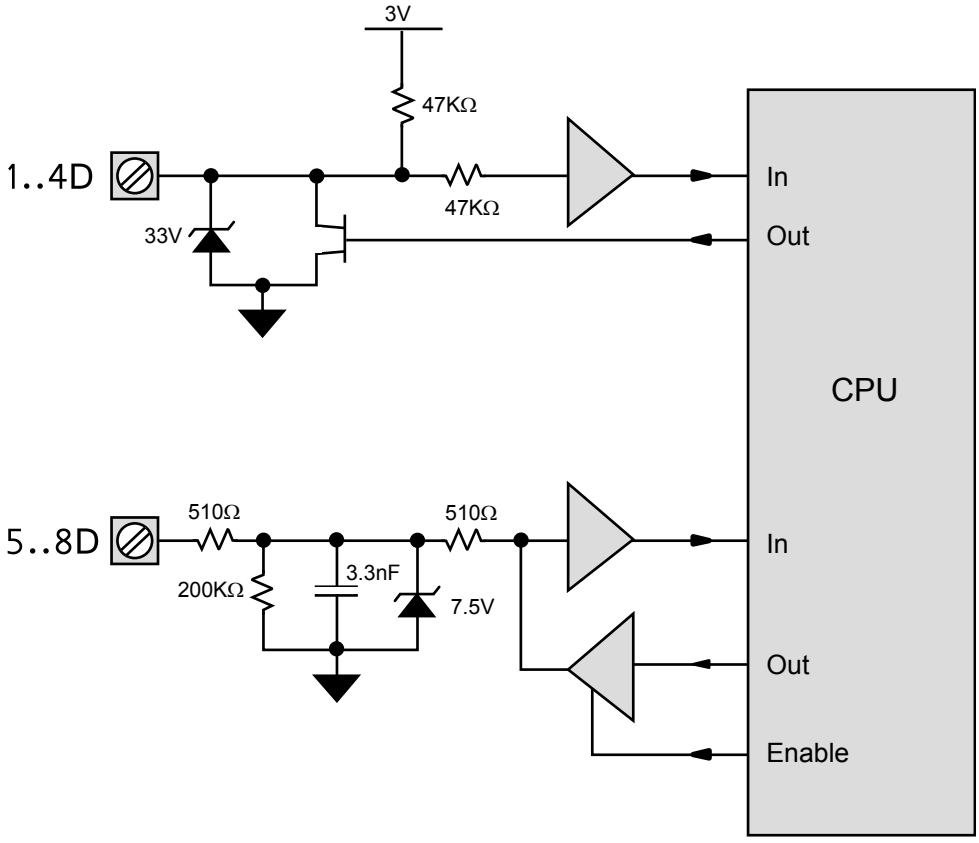


Figure 117 Digital Circuit (DT80 channel numbers shown)

Figure 117 shows a simplified circuit diagram for the DT80's eight digital I/O channels. As can be seen, the channels can be divided into two groups, **1D**-**4D** and **5D**-**8D** (**1D-3D** and **4D** for DT81/82E). While these two groups have different hardware characteristics (discussed below), all eight channels are accessed and used in much the same way.

Each of the digital channels is bidirectional; it can be used as either:

- a digital input (for monitoring the state of a relay or logic signal), or
- a digital output (for driving a relay or other control device)

Warning Beware of conflicts when using the *DT80*'s bi-directional digital channels (**1D** to **8D**). For example, if a device such as a PLC is actively driving one of these channels and you program the *DT80* to also drive the same channel as an output (for example, `1DSO=0`), then a conflict exists. This has the potential to damage the digital channel or the driving source. We recommend placing a series resistor between the digital channel and the signal source to limit the current that can be driven into the channel. When choosing the resistor's value and power rating, be sure to consider the source's output voltage, drive

current and operating frequency.

Digital Inputs

The *DT80*'s 8 digital I/O terminals (4 for DT81/82E) can be read individually, or can be read as 4 or 8 bit words.

The following channel types are used to read the states of digital inputs:

Channel Type	Valid Channel Numbers	Description
DS	**1-8** *(DT80/85)* **1-4** *(DT81/82)*	**Digital State**: returns the state of digital input; 0=low, 1=high
DN	**1-5** *(DT80/85)* **1** *(DT81/82)*	**Digital Nybble**: returns the state of four consecutive digital inputs starting at the specified input as a 4-bit number (0-15). The specified input will form the least significant bit of the result.
DB	**1**	**Digital Byte**: returns the state of all eight digital inputs as an 8-bit number (0-255). Input **1D** is the least significant bit.

For example, if channel **3DN** returns the value 13 (binary 1101) then this indicates that input **3D** (lsb) is high, **4D** is low, **5D** is high and **6D** (msb) is high

Channel Options

The following channel options are applicable to digital input channel types:

- **channel factor**: for the multi-bit channel types (**DN**, **DB**), the channel factor is a bitmask which specifies which digital inputs to read. The default values for **DN** and **DB** are 15 and 255 respectively (i.e. read all bits)

For example, **2DN(7)** (bitmask = 0111 binary) will return the state of inputs **2D**, **3D** and **4D** in bits 0 (lsb), 1 and 2 respectively. For input **5D** the mask bit is zero so it is not read and bit 3 (msb) of the returned value will always be zero. **5D** can then be used as an output if desired, e.g.

```
2DN(7)      simultaneously read inputs 2D,3D,4D
5DSO=1      drive 5D as an output
```

Connecting to Digital Inputs

The two groups of digital input channels have different electrical characteristics. In particular:

- Inputs **1D-4D** (**1D-3D** for DT81/82E) include a 47k pull-up resistor. The default state (if nothing is connected) is therefore high. This in turn means that channels **1..4DS** will return 1 if the inputs are not connected.
- Inputs **5D-8D** (**4D** for DT81/82E, none for DT82I) include a 200k pull-down resistor. Their default state is therefore low (0). So if all 8 inputs are disconnected then **1DB** will return 15 (00001111).

Warning The *DT80*'s digital inputs are not reverse-polarity-protected. Therefore ensure signal polarity is correct — positive to numbered terminals, negative to **DGND** terminals — before connecting signals to the *DT80*'s digital inputs.

Warning Do not apply more than 30Vdc to inputs **1D**-**4D** (**1D-3D** for DT81/82E), and do not apply more than 20Vdc to inputs **5D**-**8D** (**4D** for DT81/82E).

DI1 – Relay Inputs

Voltage-free relay contact closures can easily be detected on channels **1D-4D** (**1D-3D** for DT81/82E) by wiring the relay contacts between the input pin and **DGND**, as shown below.

Channels **5D-8D** (**4D** for DT81/82E) are less suitable for relay contact inputs, but they can still be used, for example if the contacts are wired between the input pin and an external 3-20V dc supply (or one of the DT85/DT80 Series 2's power outputs, **12V** or **PWR OUT**).

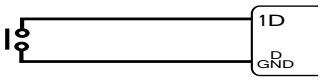


Figure 118: Wiring for reading contact closures on digital inputs

To measure	Use the command
state	**1DS** (0 = contacts closed, 1 = contacts open)

DI2 – Logic Inputs

Actively driven logic signals can be directly connected to all input channels, provided that the input levels are within the specified limits; see *Input Characteristics* (P307)

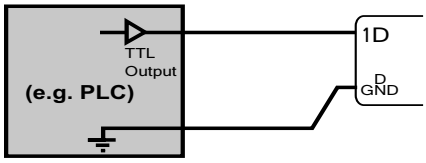


Figure 119: Wiring for reading TTL level signals on digital inputs

To measure	Use the command
state	**1DS** (0 = low, 1 = high)

Other Considerations

Scan Rate

The digital input channels are scanned at 17ms intervals (60Hz), while the *DT80* is awake. This means that the minimum input pulse width is **17ms** – shorter pulses may not be recognised.

Schedule Triggers

Digital input transitions can be used to trigger a report schedule, or a schedule can be configured to only run if a digital input is in a particular state.

See *Trigger on External Event* (P48) for more details.

Sleep Mode

Digital inputs are not scanned while the *DT80* is asleep.

However, a high to low digital input transition can be used to wake the *DT80* by connecting the digital input in parallel with the **WK** (wake) terminal. The *DT80* can then be programmed so that each time an external pulse occurs the *DT80* will wake and run an event triggered schedule.

For example, if digital input 4 is also wired to the **WK** terminal then a typical schedule definition might be:

```
RA4-E 1..3TT
```

Note that the digital input must stay low until the *DT80* is fully awake. A short pulse (less than about 1-2 seconds) will still wake the logger, but the *DT80* may not "see" the high-to-low transition, in which case the edge-triggered schedule will not run.

Digital Outputs

The *DT80*'s 8 digital I/O terminals (4 for DT81/82) can also be used as outputs, either individually, or as 4 or 8 bit words.

The following channel types are used to control the states of digital outputs:

Channel Type	Valid Channel Numbers	Description
DSO	1-8 *(DT80/85)* 1-4 *(DT81/82)*	**Digital State Output**: sets the state of digital output; 0=low, 1=high
DNO	1-5 *(DT80/85)* 1 *(DT81/82)*	**Digital Nybble Output**: sets the state of four consecutive digital outputs starting at the specified output.
DBO	1	**Digital Byte Output**: sets the state of all eight digital outputs.
RELAY	1	**Relay Output**: sets the state of the latching **RELAY** output: 0=open, 1=closed
WARN	1	**LED output**: sets the state of the **Attn** LED: 0=off, 1=on

For example:

```
7DSO=1      sets output 7D high
5DNO=5      (binary 0101) sets 8D low, 7D high, 6D low and 5D high
1DB=255     (binary 11111111) sets all outputs high
1RELAY=1    closes RELAY output contacts
```

Channel Options

The following channel options are applicable to digital output channel types:

- **channel factor**: for the multi-bit channel types (**DN0**, **DB0**), the channel factor is a bitmask which specifies which digital outputs to alter. The default values for **DN0** and **DB0** are 15 and 255 respectively (i.e. set all bits)

- **channel factor**: for the single-bit types (**DSO**, **RELAY**, **WARN**) the channel factor is a delay value (ms). The *DT80* waits for the specified number of milliseconds after setting the output state. Default is 0, i.e. no delay. If the **R** option is specified then the default and minimum delay setting is 10ms.
- **R** (**reset**) After setting the output bit(s) to the specified state(s) and waiting for the delay time, the output(s) will then be set to the opposite state. In other words a pulse will be generated.
- **PT** (**precise timing**) – see *Delay Accuracy* (P267)

For example:

```
2DNO=1CV
```

will output the lower 4 bits of 1CV on outputs 5D, 4D, 3D and 2D (all other outputs wil be unchanged), while

```
2DNO(7)=1CV
```

(bitmask = 0111 binary) will output just the the lower 3 bits of 1CV on outputs 4D, 3D and 2D. For digital output 4D the mask bit is 0 so its state will not be affected.

Digital Output Operation

All digital output channels are initialised to their default states on initial power-up or soft reset (**INIT**). Entering a new job does not initialise the digital outputs.

A hard reset (power loss or **HRESET**) will also normally re-initialise the digital output states. This behaviour can, however, be overridden by setting:

```
PROFILE STARTUP MAINTAIN_OUTPUTS=YES
```

in which case digital outputs 1..8DSO and 1RELAY will be restored to their previous states following a hard reset.

The default states are summarised below:

Channel	Default state	Comments
1..4DSO *(DT80/82I/85)* **1..3DSO** *(DT81/82E)*	1	output pulled up (high), controlled load OFF
5..8DSO *(DT80/85)* **4DSO** *(DT81/82E)*	0	output driver disabled, pulled down (low)
1RELAY	0	contacts open
1WARN	0	LED off

Note that if one of the digital outputs or the latching relay is being used to control power to a modem (see *Powering the DT80's Modem* (P177)) then that output will not be reset during a soft reset (**INIT** command).

A digital output command, e.g. **1DSO(20,R)=1** is processed as follows:

1. First, the output (or outputs for **DNO**/**DBO**) is set to the specified state; if no state is specified (i.e. no **=1** or **=0** on the end) then nothing is done.
2. Then the *DT80* waits for the specified delay, if any. If a state was specified and the **R** option was also specified then the default delay is 10ms, otherwise 0ms.
3. Then, if **R** is specified, the output(s) is/are inverted.
4. Finally, the output value as at Step 2 is returned.

The current state of any digital output is thus returned when a digital output command is evaluated. For example, typing **2DSO** will return the state to which the output was last set. This will not necessarily reflect the actual state of the **2D** terminal (use **2DS** to read the actual state). And if **2DSO(R)** is entered then the state of **2D** will be inverted and the original state will be returned.

Connecting to Digital Outputs

As noted above, the two groups of digital channels have different electrical characteristics. In particular:

- Outputs **1D-4D** (**1D-3D** for DT81/82E) use an open-drain FET output driver. This can sink up to 100mA @ 30Vdc so it can drive a low voltage actuator or relay or LED directly. A 47k pull-up resistor (to approx. +4V) is also included, allowing logic devices to be driven.
- Outputs **5D-8D** (**4D** for DT81/82E, none for DT82I) are not suitable for directly driving loads such as relays or LEDs. Logic devices can however be driven. Note that each of these output drivers is tri-stateable.

When the open-drain outputs are used to directly drive loads, the load will be on when the output is in the low state. Thus if a load was wired up to output **1D** you would use **1DSO=0** to turn the load on and **1DSO=1** to turn it off.

The default state of the output drivers on second group of channels is disabled (tri-stated). This allows these channels to be used as inputs.

DO1 – Driving a Relay

Loads of up to 100mA @ 30V dc can be directly driven by the open-drain digital outputs **1D-4D** (**1D-3D** for DT81/82E). Note that inductive loads such as relays should include a reverse diode to limit transients, as shown below.

The power supply for the load can be an external supply, or you can use the power outputs provided on the DT85/DT80 Series 2 (**12V** or **PWR OUT**).

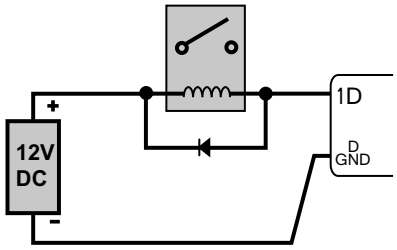


Figure 120: Wiring for driving an external relay

Action	Use the command
energise relay	`1DS0=0`
de-energise relay	`1DSO=1`

DO2 – Driving a LED

A LED indicator can also be directly driven by the open-drain digital outputs **1D-4D** (**1D-3D** for DT81/82E).

The value of the current limiting resistor should be chosen to suit the supply voltage and LED characteristics. A value of 1kΩ will set a LED current of about 10mA if a 12V supply is used.

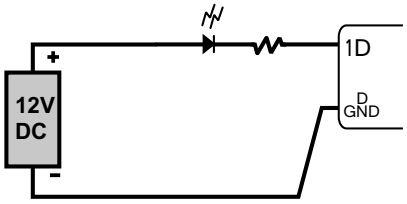


Figure 121: Wiring for driving an external LED

Action	Use the command
turn LED on	`1DS0=0`
turn LED off	`1DSO=1`

DO3 – Logic Outputs

Any of the digital outputs (**1D-8D**) can be used to drive a TTL-compatible logic input, as shown below

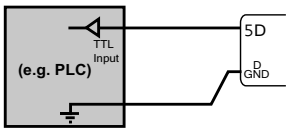


Figure 122: Wiring for driving external logic

Action	Use the command
set output high	`5DS0=1`
set output low	`5DSO=0`

DO4 – Driving a Relay Using 5D-8D

The active-drive digital outputs **5D-8D** (**4D** for DT81/82E) cannot directly drive loads such as relays.

However, an external transistor can be used to increase the current sink capacity so that a relay (or LED) can be controlled by these outputs.

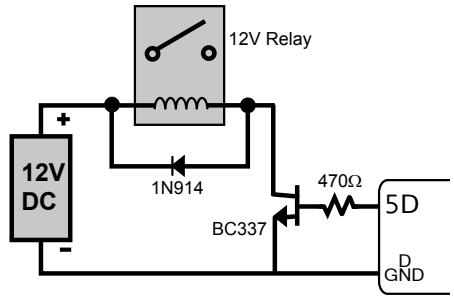


Figure 123: Wiring for driving an external relay using an external transistor

Action	Use the command
energise relay	`1DS0=1`
de-energise relay	`1DSO=0`

Note that the sense is opposite to that shown in *DO1 – Driving a Relay* *(P265)* – the *DT80* output needs to be driven high in order to turn on the NPN transistor shown.

DO5 – Latching Relay Output

The *DT80*'s latching relay output can be used to directly switch loads of up to 1A @ 30V, as shown below.

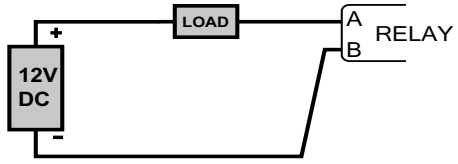


Figure 124: Wiring for controlling a load using relay output

Action	Use the command
turn load on	`1RELAY=1`
turn load off	`1RELAY=0`

Other Considerations

Reading Digital Outputs

If you read the value of a digital output channel, e.g. by entering `1DSO`, then the value returned is the state to which the output was last set. This will not necessarily be the same as the state returned by `1DS`, which reflects the actual state on the **1D** terminal.

If an open-drain output (**1D-4D** for DT80) is set high (e.g. `1DSO=1`), the terminal is not driven by the *DT80* and is free to be pulled low by an external device. If this occurs then `1DSO` will still return 1, but `1DS` will return 0, the actual state of the input.

For the *DT80*'s active-drive outputs (**5D-8D** for DT80), things are slightly more complicated due to the fact that the output has three states: driving high, driving low, or disabled (tri-stated). The rule is that the output driver is switched on when the digital output channel is set (e.g. `5DSO=0` or `5DSO=1`) and it then stays on. If the digital input channel is subsequently read (e.g. `5DS`), then the driver will be switched off (and it will stay off) to allow the terminal to be read as an input.

The active-drive outputs include a weak (200k) pull-down resistor. When the output driver is switched off, and in the absence of any external device driving the terminal, it will therefore normally read low (i.e. `5DS` will return 0). Note, however, that the first time it is read after the output driver is switched off it may still read high (if the output had previously been set high), due to capacitive effects.

For example,

```
6DSO(R,100)=1 6DS(W) DELAY=500 6DS
```

will output a 100ms positive going pulse on **6D**, then tri-state the output, wait 500ms then read the state of **6D** (which is presumably now being driven by an external logic device).

Sleep Mode

The states of all digital outputs are maintained while the *DT80* is asleep. Note also that the **RELAY** output uses a latching relay, so no extra current is required to hold it in the closed state.

Power Loss

If the *DT80* loses all power then all outputs will revert to their default state, including the **RELAY** output. If the **MAINTAIN_OUTPUTS** profile setting is enabled then the outputs will be restored to their former state when power is restored.

Alarm Digital Actions

One or two digital outputs can be configured to follow the state of an alarm. That is, when the alarm is inactive the output(s) are in their default state (1 for **1..4DSO**, 0 for **5..8DSO**, **1RELAY** and **1WARN**) and when the alarm is active the output(s) will be in their non-default state. *Alarm Digital Action Channels* *(P79)* for more information.

Delay Accuracy

The actual pulse width generated by the Delay option for **DSO** will not necessarily be exactly as specified. For delays of 20ms or less it will be close (within 1ms). For longer delays the resolution is +/- 16ms however it is guaranteed that the duration will be at least the specified time.

The **PT** (precise timing) channel option may be specified to force a precise delay time, even if the duration is greater than 20ms. For example:

```
1DSO(PT,500,R)=0
```

will generate a 500ms +/- 1ms duration pulse. Note however that during this time all logger operations including communications, display updates and sampling will be suspended.

Note Performing long delays using the Delay option is not recommended as it can prevent the timely evaluation of other schedules. This is true regardless of whether the **PT** option is specified.

Counters – Low Speed

The digital input channels **1D-8D** can also double as low speed counter inputs (up to 25Hz).

The **C** (counter) channel type returns the number of positive-going transitions seen on the specified digital input (**1D-8D**). For example the channel **3C** will return the number of pulses seen on digital input **3D**.

The counter value is a signed 32-bit integer.

Any of the digital input wiring configurations can be used. That is, either contact closures or logic pulses can be counted.

Channel Options

The following channel options are applicable to low speed counters:

- the **channel factor** specifies a counter "wrap value". The counter will reset to 0 (or "wrap around") when this value is reached. For example, if 8 pulses are received on input **4D** then channel **4C(3)** will count in the sequence 1, 2, 0, 1, 2, 0, 1, 2 so after 8 pulses the value 2 will be returned.
- **R** (reset): Counter will be cleared to 0 after returning its current value.

Using Low Speed Counters

Scan Rate

The digital input channels are scanned at approx. 20ms intervals (50Hz). This means that for low speed counter channels:

- the minimum input pulse width is **20ms** – shorter pulses may not be recognised.
- the maximum input count frequency, assuming a 50% duty cycle, is **25Hz**.

Use the high-speed counter channels *(P268)* for higher count frequencies.

Sleep Mode

Digital inputs are not scanned while the *DT80* is asleep so any transitions which occur during sleep will not be counted. Use the high-speed counter channels *(P268)* if you need the logger to continue to count pulses even while asleep.

Schedule Triggers

Counter channels can be configured to trigger a schedule when the counter reaches its specified wrap value (at which point it resets to 0). See *Trigger on External Event* *(P48)* for more details. For example,

```
RA2C(10) 1TK
```

will measure a temperature on every 10th pulse received on digital input **2D**.

Presetting Counters

The count value for a digital input channel can be preset using an expression, e.g.

```
RA1M 8C=1000  RB2S 8C
```

will reset the counter to 1000 once per minute. So if a 1Hz signal is now applied to input **8D** you would expect the values returned every 2s for channel **8C** to follow a sequence similar to:

1000, 1002, 1004 ... 1056, 1058, 1000, 1002 ...

Setting Counter Wrap Value

Note that a counter's wrap value (channel factor) is applied when the channel is defined (i.e. when the job is entered), not

when it is evaluated. Also, setting the wrap value has the side effect of resetting the count value to zero. This implies that:

- a particular counter's wrap value need only be specified once in the job. It does not need to be specified every time the counter is evaluated.
- If querying a counter using the immediate schedule (e.g. by periodically typing "**1C**"), do not specify a wrap value each time. Each time you evaluate an immediate channel you are also defining it, so the counter value will always be returned as zero if you specify a wrap value each time.

Counters – High Speed

The *DT80* provides four dedicated counter inputs, labeled **1C-4C** (7 counters **1C-7C** on DT85/85L Series 3). These provide for high speed pulse counting (up to 10kHz) and can also function as phase encoder inputs.

The **HSC** (high speed counter) channel type is used to access these counters. For example, **2HSC** will return the number of positive transitions seen on the **2C** counter input.

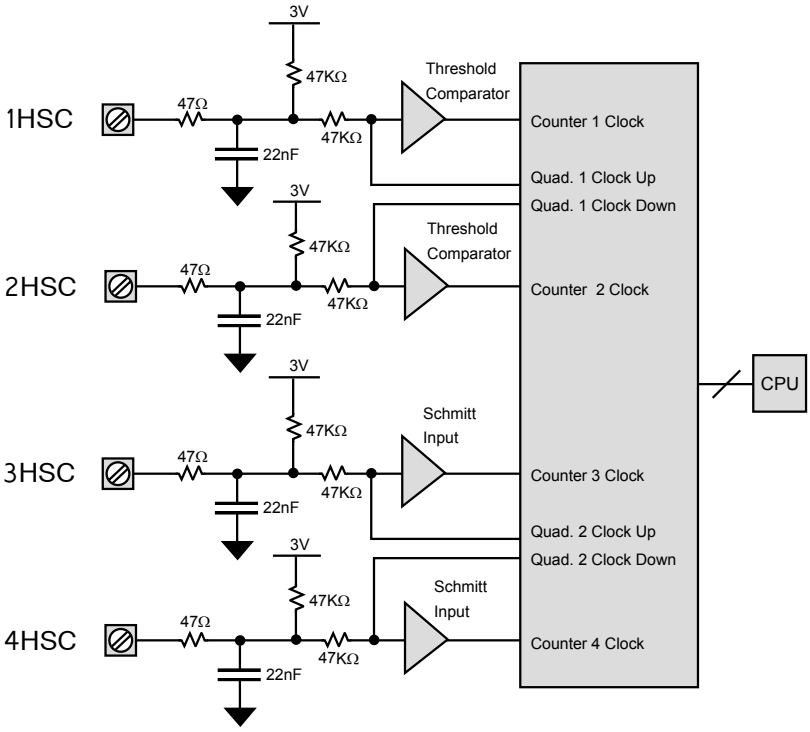


Figure 125 High Speed Counter Channels

Figure 125 shows a simplified circuit diagram for the *DT80*'s hardware counter inputs. As can be seen, the channels can be divided into pairs of inputs, **1C-2C** (counter channels **1HSC** and **2HSC**) and **3C-4C** (**3HSC** and **4HSC**); also **5C-6C** on DT85/85L Series 3. Each pair can be used as either:

- two independent counter inputs, for pulse counting, or
- a single phase encoder (quadrature) input, for use with position sensors that provide phase encoded outputs ("A" and "B"). See *Phase Encoders* *(P270)*

Note that on the DT81, only the **3C-4C** inputs can be used with a phase encoder.

Channel Options

The following channel options are applicable to high speed counters:

- the **channel factor** specifies a counter "wrap value", as for the low speed counters. The counter will reset to 0 (or "wrap around") when this value is reached.
- **R** (reset): Counter will be cleared to 0 after returning its current value, as for the low speed counters.
- **LT** (low threshold): This option is only applicable to counter inputs **1C** and **2C** (i.e. counter channels **1HSC** and **2HSC**). It selects low level input thresholds ("low" threshold 2mV and "high" threshold 7mV), as opposed to regular (TTL-level) thresholds.

Connecting to Counter Inputs

Counter input channels **1C-2C** and **3C-4C** have different electrical characteristics. In particular:

- Inputs **1C-2C** include selectable TTL or low-level input thresholds. Low thresholds (selected by using the **LT** channel option) allow direct connection to sensors whose output is only a few mV, e.g. inductive-pickup flow sensors.
- Inputs **3C-4C** (and **5C-7C**) use a standard TTL level Schmitt trigger input.

Relay Contact Inputs

Voltage-free relay or switch contact closures can be counted on high speed counter channels by wiring the relay contacts between the input terminal and **DGND** in the same way as for a digital input.

All inputs include low-pass filtering to assist in "debouncing" mechanical switch or relay inputs. For voltage-free contact inputs this limits the maximum count rate to approximately 500Hz.

Logic Inputs

TTL level logic outputs from external equipment may also be directly connected to a counter input in the same way as for a digital input. For actively driven inputs such as these, the maximum count rate is approximately 10kHz.

Low Level Inputs

Inductive pickup sensors such as flow meters often have an output pulse amplitude of only a few millivolts. These can, however, be directly connected to inputs **1C** or **2C**. The **LT** channel option must be specified in order to set the *DT80*'s input threshold levels appropriately, e.g. **1HSC(LT)**.

Refer to the Specifications for more details on the counter input characteristics.

Special Count Modes

Counter input **3C** (i.e. channel **3HSC**) supports some special count modes. These are controlled by the P27 setting, as follows:

Setting	Description
P27=0	**Normal** (default setting) – **3HSC** returns the number of pulses seen on the **3C** input
P27=1	**Gated 32kHz** – **3HSC** increments at 32768Hz while input **3C** is low. This can be used for measuring pulse widths.
P27=2	**Gated 3C** – **3HSC** returns the number of pulses seen on input **3C** while input **4C** is low. This can be used for measuring a short burst of pulses.
P27=3	**Fixed 1024Hz –** **3HSC** continuously increments at 1024Hz. This can be used for general high resolution timing.

Counting While Asleep

The high-speed counter inputs continue to function while the *DT80* is asleep.

However, it is important to note that each hardware counter is 16 bits wide. (Count values are maintained and returned as 32-bit values, but the physical hardware counters attached to inputs **1C-4C** are 16-bit.) If more than 65536 pulses occur while the *DT80* is sleeping then the hardware counter will overflow, and this will cause an inaccurate count value to be returned when the *DT80* wakes.

It is therefore necessary to ensure that the *DT80* is programmed to wake often enough to ensure that the hardware counters can be read before they overflow.

For example, if the average counter input frequency is 100Hz then the *DT80* must be programmed to wake at least every 65536/100 seconds (about every 10 minutes). This can be done by including a 10-minute schedule in the job, e.g.

```
RA10M 1HSC(W)
```

Most of the other comments made above regarding digital input counter channels apply equally to the high speed counter channels. For example, HSC channels can be preset to a particular starting value (e.g. **2HSC=1CV*10**), HSC channels can trigger a schedule when they wrap, and so on.

Other Considerations

Signal Edges

Counters increment on the rising edge of the count input signal.

For gated modes (P27=1 and P27=2), the gate signal is sampled on the falling edge of the count input signal.

Schedule Triggers

High speed counter channels can be configured to trigger a schedule when the counter reaches its specified wrap value (at which point it resets to 0). See *Trigger on External Event* *(P48)* for more details. For example,

```
RA2HSC(100) 1TK
```

will measure a temperature on every 100th pulse received on counter input **2C**.

Presetting Counters

The count value for a high speed counter channel can be preset using an expression, e.g.

```
RA1M 1HSC=1000  RB2S 1HSC
```

will reset the counter to 1000 once per minute. So if a 1Hz signal is now applied to input **1C** you would expect the values returned every 2s for channel **1C** to follow a sequence similar to:

1000, 1002, 1004 ... 1056, 1058, 1000, 1002 ...

Setting Counter Wrap Value

Note that, as with low speed counters, a counter's wrap value (channel factor) is applied when the channel is defined (i.e.

when the job is entered), not when it is evaluated. Also, setting the wrap value has the side effect of resetting the count value to zero. As discussed earlier, this implies that the wrap value should therefore normally only be specified once for each counter channel.

Phase Encoders

Not available on DT82E

A phase encoder is a device for measuring relative angular or linear position. As it rotates or moves, it outputs two streams of pulses ("A" and "B") whose phase relationship (A leading or B leading) indicates the direction of travel.

The *DT80*'s **PE** channel type decodes these pulses and returns a signed position value in counts. The count may be positive or negative depending on the direction of travel.

As mentioned in *Counters – High Speed* *(P268)*, the *DT80*'s four high speed counter inputs are set up in pairs: **1C/2C** and **3C/4C**; also **5C**/**6C** on DT85/85L Series 3. Each pair can be used as either two independent counters, or a single phase encoder input. (For DT81, only the **3C/4C** pair can be used as a phase encoder input.)

Note that the "mode" of a counter channel pair (i.e. whether it operates as two counters or a single phase encoder channel) is set when the channel is *defined* (i.e. when the job is entered), not when it is *evaluated.* This implies that a particular counter input pair *cannot* be read as a phase encoder value at one point in a job, and as a pair of counters at another. In other words, if your job defines a channel **1PE** then it should *not* also define channels **1HSC** or **2HSC**, and vice versa.

The following table summarises the options for using phase encoder channels:

Model	Channel	"A" input	"B" input	Notes
DT80/82/85	**1PE**	**1C**	**2C**	Do not use **1HSC** and **2HSC** channels
	2PE	**3C**	**4C**	Do not use **3HSC** and **4HSC** channels
DT85/85L-3	**3PE**	**5C**	**6C**	Do not use **5HSC** and **6HSC** channels
DT81	**1PE**	**3C**	**4C**	Do not use **3HSC** and **4HSC** channels

Channel Options

The following channel options are applicable to **PE** channel types:

- the **channel factor** is not used for phase encoder channels.
- **R** (reset): Position value will be cleared to 0 after returning its current value.

Phase Encoder Operation

The following diagram illustrates how the reported **PE** position values relate to the phase encoder pulses received on the counter inputs. In particular, note that a pulse is counted on each edge of the A and B inputs. This is sometimes referred to as "x4" mode, because if the encoder speed is such that it generates a 100Hz pulse train on its A and B outputs then the *DT80*'s position count will increment at 400Hz.

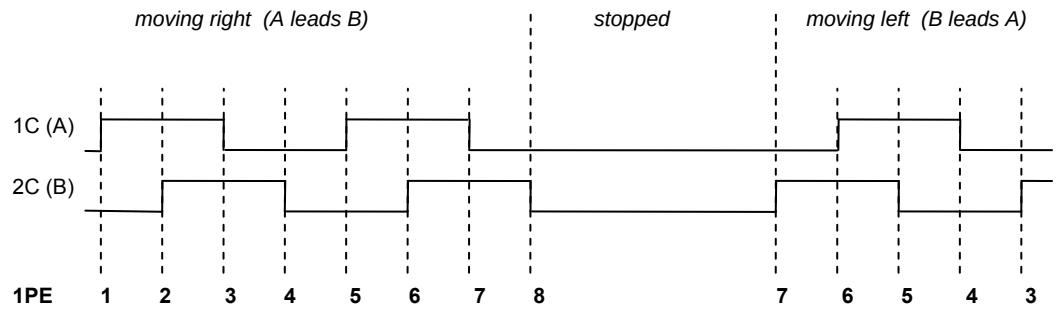


Figure 126: Relationship between phase encoder signals and reported position (1PE) value

P1 – Phase Encoder Inputs

The following diagram shows the connection of a phase encoder to the counter inputs on a DT80 or DT85. (For DT81 you would use the **3C** and **4C** inputs.)

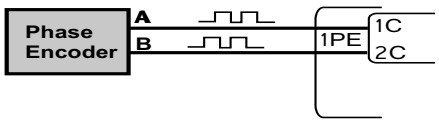


Figure 127: Wiring for reading a phase encoder (quadrature) signal

To measure	Use the command
position (in counts)	**1PE**

Other Considerations

Sleep Mode

The high-speed counter inputs continue to function while the *DT80* is asleep, so the phase encoder inputs will too.

As discussed in the High Speed Counter section *(P269)*, it is important to ensure that the 16-bit hardware counters do not overflow during sleep. The *DT80* calculates the encoder position in software, by subtracting the count values read from the "up" and "down" hardware counters. This means that incorrect readings will result if there are more than 65536 pulses in either direction while the *DT80* is asleep.

Presetting Counters

The count value for a phase encoder channel can be preset using an expression, e.g.

```
RA3-E 1PE=0
```

will reset the encoder position to 0 when a button wired to digital input 3 is pressed.

Examples – Digital and Counters

Pulse Train Output

The schedule command

```
RA2S 6DS0(500,R)=1
```

produces a pulse train from channel **6D** which is HIGH for 0.5s and LOW for 1.5s.

Sensor Power Control

In the schedule command

```
RA20M D T 4DSO(1000)=0 1..4V 4DSO=1
```

digital state output 4 controls a relay that switches the power supply to a group of sensors. Every 20 minutes the sensors are powered up, the system waits one second while the sensors settle, the sensors are scanned, and the sensor power supply is turned off again.

Manual Control

The polled schedule (see *Trigger on Schedule-Specific Poll Command (P49)*) can also be used to switch digital state output channels. For example, the command

```
RBX 3DSO(5500,R)=0
```

turns a load connected to channel **3D** ON for 5.5 seconds when an **XB** poll command is received.

Frequency Measurement

The **R** channel option can be used to measure the frequency of an input signal, e.g.

```
RA1S 1HSC(R,RS)
```

will return the frequency in Hz of an input signal on channel **1C**, while

```
RA10S 1HSC(R,RS)
```

will do the same thing but resolve down to 0.1Hz.

The **RS** option divides the channel value (number of pulses) by the time since the last sample, yielding a frequency.

This technique can also be used for the digital input channels (**1D-8D**), e.g.

```
RA1S 7C(R,RS)
```

will return the frequency in Hz of an input signal on channel **7D**, in the range 1-30Hz.

SDI-12 Channel

Not available on DT82I

About SDI-12

SDI-12 is a serial communications protocol for interfacing multiple microprocessor based sensors to a data logger. SDI-12 uses a shared three-wire "bus" – 12V power, data (0-5V signaling levels) and ground – and operates at a data rate of 1200 baud.

Each sensor connected to an SDI-12 bus is configured with a unique **address**, which is usually just a single digit 0-9. The data logger specifies this address when it requests data from the sensor. This transmission will be received by all sensors, but only the one with the matching address will respond. If two sensors have the same address then they will both try to transmit at once, resulting in garbled communications.

The SDI-12 standard has undergone a number of revisions; at the time of writing the current version is 1.3. (1.0 was released in 1988, 1.2 in 1996 and 1.3 in 2000.) Not all sensors support the latest version. The *DT80* can determine which version of the standard a given sensor supports, and act appropriately.

Each SDI-12 message sent by the data logger is a short (up to 5 characters) plain ASCII string, terminated by a **!** character. The response from the addressed sensor is also in ASCII format (up to 80 characters).

For more details see http://www.sdi-12.org.

SD1 – SDI-12 Sensor Inputs

The *DT80*'s tri-stateable digital I/O channels (**5D-8D** on DT80, **4D** on DT81/82E) can be used to control up to four SDI-12 buses. Up to ten SDI-12 sensors can be connected to each bus.

As shown below, an SDI-12 bus is connected to the *DT80* as follows:

- The SDI-12 **DATA** line connects to one of the digital I/O terminals **5D – 8D** (**4D** for DT81/82E)
- The SDI-12 **GROUND** line connects to the **D GND** terminal
- The SDI-12 **POWER** line may be connected to the *DT80*'s external power input terminal (**+**), or one of the power outputs on the DT85/DT80 Series 2 (**12V** or **PWR OUT**), or a separate 9.6-16V DC supply.

When connecting a sensor to the *DT80* for the first time, it's best to connect only that sensor, i.e. you should temporarily disconnect any other sensors on the same SDI-12 bus. This ensures there will be no address conflicts

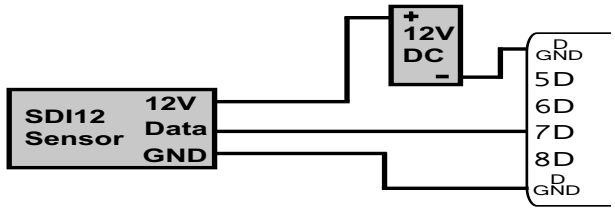


Figure 128: Wiring for an SDI-12 sensor. Up to 10 sensors can be connected in parallel to each digital channel.

To measure	Use the command
register #1 on SDI-12 device #0	**7SDI12**

Testing and Configuring an SDI-12 Device

SDI-12 Address

The first task is to determine the address of the sensor. All SDI-12 sensors are able to be set to one of at least ten different addresses. Depending on the sensor, this may be done by:

- changing a hardware setting, e.g. DIP switches
- sending an SDI-12 "change address" command (*a***A***b***!**, where *a* is the current address and *b* is the new address)
- connecting the sensor to a PC serial port and using configuration software supplied by the sensor manufacturer. You may also need to use this configuration software to configure other aspects of the device – for example the device's SDI-12 interface may be disabled by default, so you would need to enable it using the configuration software.

Consult the sensor's documentation to determine how to set its address. Note that all SDI-12 sensors are factory set to address 0. If you are only connecting one sensor to the SDI-12 bus then you can leave it set to this value.

Using SDI12SEND

The *DT80*'s **SDI12SEND** command allows you to manually send SDI-12 commands to the sensor for testing and configuration purposes. The format of this command is as follows:

```
SDI12SEND channel "string"
```

where:

- *channel* is the digital I/O channel (**5** – **8**) (**4** for DT81/82E)
- *string* is a valid SDI-12 command string to send to the device. All commands start with the sensor address (**0** – **9**) and end with a **!** character.

If there is a reply from the device then it will be displayed, assuming the **/M** (enable messages) and **/h** (free format) switches are set.

For example, the *a***I!** command (*a* = address) should result in the sensor returning an identification string, e.g.

```
SDI12SEND 5 "0I!"
5SDI12: 0I!012SENTEK  XEPI  1165FA14F000800
```

In this example a sensor with address **0** is connected to digital channel **5D**. The output of the **SDI12SEND** command shows the complete transaction: the first few characters (up to the `!`) are the command string that was sent, the rest are the response from the sensor. In this case, the response indicates:

- `0` – the sensor's address
- `12` – the version of SDI-12 supported by the sensor (1.2)
- `SENTEK` – the sensor manufacturer
- `XEPI` – the model name
- `116` – the sensor firmware version
- `5FA14F000800` – other sensor details, e.g. serial number

If a valid response is not received, an error message will be displayed, e.g.:

```
SDI12SEND 5 "3I!"
5SDI12: 3I! *no response
```

In this case the command was sent to the address 3, which is the wrong address. This error may also indicate a wiring problem, or perhaps the SDI-12 interface on the device has not been enabled.

Errors such as "`*framing error`", possibly in conjunction with a garbled looking message, generally indicate an address conflict (more than one device with the same address is connected) although it may also indicate an electrical noise issue.

Reading Data from SDI-12 Devices

Measurement Modes

SDI-12 sensors can operate in one of two different modes:

- **Measure on demand** is the traditional SDI-12 method, which all sensors support. The sensor is idle (typically in a low power mode) until it is woken by the data logger sending it a measurement request. The sensor then takes the measurement and then, possibly several seconds later, returns the data.
- **Continuous measurement** is an alternative method, supported by some SDI-12 sensors. The sensor takes measurements at regular intervals, then when the data logger requests data it immediately replies with the last reading it took.

In Measure On Demand mode the *DT80* must send a request then wait until the measurement is ready, which may be immediate or it may take several seconds – depending on the sensor. During this time no other schedules will run, and no commands will be executed (similar to a **DELAY** channel).

Measure On Demand mode is most suitable in applications where the sensor is being polled infrequently. This mode minimises system power usage because the sensor only takes a measurement when it is requested to.

Continuous measurement mode is suited to applications where the logger needs to poll the sensor relatively often, or it is running other schedules which should not be delayed. Note that the sensor may need to be sent some special commands (either via SDI-12 or via a separate RS232 configuration interface) to enable continuous mode, set the measurement rate and so on.

Check the sensor's documentation to see whether continuous measurement mode is supported. If it is, your first decision is whether you want to use it.

Registers

Most SDI-12 devices can measure a number of different quantities. For example, a device might have 4 temperature sensors plus 8 moisture sensors, i.e. it can measure 12 distinct quantities.

In *DT80* parlance, each individual data item (quantity that can be measured) is termed a **register**. An SDI-12 device may then divide its particular set of registers into a number of groups, or **register sets**. For example the abovementioned device might define register set #2 as the 4 temperature sensors, and register set #3 as the 8 moisture sensors.

The measurement process then proceeds as follows:

1. The *DT80* sends a request message (*a***C***r***!**) to the SDI-12 device, specifying the register set (*r*) of interest – only one register set can be requested at a time. (If *r* is 0 then it is omitted, i.e. *a***C!** is sent.)
2. The sensor will now measure and update all of the registers in the specified set.
3. After the required time interval, the *DT80* sends a second message (*a***D0!**) to request the actual data values.
4. The sensor replies immediately, sending some or all of the register values.
5. If not all register values were sent, the *DT80* may send further *a***D***n***!** message(s) to request the remainder.

In Continuous Measurement mode the process is considerably simpler:

1. The *DT80* sends a message (*a***R***r***!**) to request the most recent data values for register set *r*.
2. The sensor replies immediately, sending all of the register values.

The SDI12 Channel Type

The *DT80*'s **SDI12 channel type** allows you to read a data value from an SDI-12 device in much the same way as you would read a voltage using the **V** channel type – without worrying about the technicalities of the SDI-12 protocol. There are four of these channels available, **5..8SDI12**, corresponding to the four SDI-12 compatible digital I/O channels (**5D – 8D**).

When an **SDI12** channel is used, you need to specify additional information via channel options. The following channel options apply:

Option	Function
AD*a*	**Address**: specifies the SDI-12 address of the sensor to read (**0**-**9**). If not specified, **0** is assumed
R*nnn*	**Register**: specifies the particular register to return. If the sensor defines more than one register set then the hundreds digit specifies the register set. If the hundreds digit is zero or not specified then the sensor's default register set (register set #0) is assumed. The tens and units digits specify the register number within the register set: **1** for the first data item in the set, **2** for the second, and so on. If this option is not specified, **001** is assumed (which would be suitable for a sensor that only returned one value) Note that **R2** is equivalent to **R002** (not **R200**).
CM	**Continuous Measurement**: If this option is present then the *DT80* will use Continuous Measurement Mode. The sensor is assumed to have been configured to take continuous measurements.

*R*nnn *Settings*

Some sample settings for the **R***nnn* channel option are shown below:

Option	Data Value (Register) to Read
(none)	First data value in default register set (register set #0)
R001 (or **R1**)	First data value in default register set (register set #0)
R019 (or **R19**)	19th data value in default register set (register set #0)
R100	not valid
R101	First data value in register set #1
R344	44th data value in register set #3

For example, suppose a particular SDI-12 device measures 9 different quantities in one go (i.e. it has 9 registers in its default register set). These 9 values would then be returned to the data logger using an exchange of messages similar to the following (underlined text is sent by the data logger, the remainder is returned by the sensor):

```
0D0!0+005.7541+068.0368+017.6721+054.3521+052.0475+016.2069+017.1182+016.8696
0D1!0+019.1727
```

These 9 register values can then be accessed using **5SDI12(R1)** through **5SDI12(R9)**. So if you were interested in the third value in the list you would use:

```
5SDI12(R3)
5SDI12 17.7
```

As can be seen, the third value returned by the sensor (+017.6721) is the return value of the channel.

Example

Measure on Demand

In this example, the documentation for a hypothetical SDI-12 weather station states: "Send the *a***C1!** (or *a***M1!**) command to measure (1) internal temperature (degC), (2) external temperature, (3) humidity (%RH) and (4) pressure (hPa). Send the *a***C2!** (or *a***M2!**) command to measure (1) wind speed (km/h), (2) max gust and (3) direction (degrees)." The device is connected to the *DT80* using digital I/O **7D**, and has been configured with an SDI-12 address of **3**.

In this case the device has two register sets (#1 and #2), one with four registers (measured quantities), one with three. The following *DT80* job will read and log external temperature, pressure and wind speed every two minutes:

```
BEGIN"CLOUDY"
RA2M 7SDI12(AD3,R102,"Ext temp~degC")
     7SDI12(AD3,R104,"Pressure~hPa")
     7SDI12(AD3,R201,"Wind speed~km/h")
LOGON
END
```

Note If your sensor supports both the *a***M***n***!** and the newer *a***C***n***!** SDI-12 commands (most modern sensors will) then be sure to refer to the section on the *a***C***n***!** command in the sensor documentation when determining which register numbers to use. These two SDI-12 commands do much the same thing but the ordering of the returned data values may be different. The *DT80* always uses the *a***C***n***!** command in preference to *a***M***n***!**.

Continuous Measurements

The weather station documentation goes on to say "To enable continuous measurement mode (sampling every *t* seconds), use the *a***XC=***t***!** command; to disable use *a***XCD!**. [SDI-12 "**X**" commands are often used to implement device specific functions such as this.] Use *a***R1!** and *a***R2!** to return the most recent values of int temp/ext temp/RH/pressure and wind speed/gust/direction respectively."

The following job does the same thing as the previous example, but this time continuous measurement mode is used:

```
BEGIN"CLOUDY_CM"
SDI12SEND 7 "3XC=10!"  ' enable continuous mode
RA2M 7SDI12(AD3,R102,CM,"Ext temp~degC")
     7SDI12(AD3,R104,CM,"Pressure~hPa")
     7SDI12(AD3,R201,CM,"Wind speed~km/h")
LOGON
END
```

Other Considerations

Execution Time

In Measure on Demand mode, **SDI12** channels may take a significant amount of time to execute – often 10 seconds or more, depending on the sensor. During this time no other schedules or commands are executed.

Note however that the *DT80* will only request a measurement of a given register set once per schedule. So the following schedule:

```
RA1M 5SDI12(R1) 5SDI12(R3) 5SDI12(R201) 5SDI12(R4)
```

would execute as follows:

1. *DT80* requests a measurement of register set #0 (**0C!**), then waits until it is ready.
2. *DT80* reads values for registers 1, 3 and 4, which are all part of register set #0. It will probably be given values for other registers (e.g. register 2), which it will discard because they are not referenced in the job
3. *DT80* can now evaluate (i.e. return/log values for) the first two channels.
4. *DT80* requests a measurement of register set #2 (**0C2!**), then waits until it is ready.
5. *DT80* reads value for register 1 (in register set #2) and discards any other values that it receives.
6. *DT80* can now evaluate the last two channels.

Notice that the *DT80* waits for the sensor on two occasions, once for each register set.

Versions

The *DT80* automatically determines the version of the SDI-12 specification that a given sensor supports, and tailors the types of messages it sends accordingly. For example:

- Error check codes (CRCs) are used on data messages, but only if the sensor supports SDI-12 Version 1.3 or later.
- Continuous Measurement mode is only available if the sensor supports SDI-12 Version 1.2 or later.

Troubleshooting

There are two main areas where difficulties may arise when setting up an SDI-12 system

- the *DT80* cannot communicate properly with the sensor
- the sensor does not support the request you are making of it

These will be discussed in the sections below.

Diagnostic Messages

When troubleshooting an SDI-12 connection, it can often be helpful to see the actual SDI-12 messages. The *DT80* provides

a special parameter setting for this purpose:

```
P56=2
```

If this parameter setting were used with the weather station example described above (Measure on Demand mode), you might see something like:

```
7SDI12: [8] 3C1!300704
7SDI12: [25] 3D0!3+22.91+42.40+21.0+1013.9
Ext temp 42.4 degC
Pressure 1013.9 hPa
7SDI12: [8] 3C2!300603
7SDI12: [18] 3D0!3+4.29+31.43+012
Wind speed 4.3 km/h
```

which shows the measurement request message (`3C1!` or `3C2!`) and response, followed by the data retrieval message (`3D0!`) and response, for each register set.

Set **`P56=0`** to turn off these messages.

Communications Problems

If the sensor does not reply at all to a request, the *DT80* will output an error message, e.g.:

```
8SDI12(R3)
dataTaker 80 E80 - Serial device not responding (8SDI12:AD0:R3)
8SDI12 NotYetSet
```

Note also that the value returned by the channel is the special "NotYetSet" error value (see *Data Errors* *(P328)*)

The main things to check here are:

- cabling (Is the sensor powered?)
- correct **`SDI12`** channel number (In the above example the SDI-12 data wire should be connected to digital input **8D**.)
- correct SDI-12 address (In the above example the device should have been configured for address 0.)

This error message may also indicate an **address conflict** – a response was received from the sensor but it was garbled because two or more sensors tried to both transmit at the same time, which will occur if they are both configured to use the same address.

Try connecting only one sensor at a time and verifying the address of each sensor. For most sensors you can use the following command:

```
SDI12SEND 8 "?!"
8SDI12: ?!1
```

In this case the sensor has responded, stating that it has been set to address `1`.

Communications may also be affected by electrical noise or poor cable connections. If the sensor supports it, the *DT80* will request that it include an error checking code (CRC) with each data record, which the *DT80* will then check. Any corruption of these messages will then result in an error message such as:

```
dataTaker 80 E81 - Serial device invalid response (8SDI12:AD0:R1)
8SDI12 NotYetSet
```

Unsupported Functions

The other error message that you may see is:

```
5SDI12(R207)
dataTaker 80 E82 - Serial device data not available (5SDI12:AD0:R207)
5SDI12 NotYetSet
```

In this case the sensor has indicated that the requested register does not exist. The sensor either does not support register set #2 (i.e. the *a***`C2!`** command), or that register set returns fewer than 7 values.

This error may also occur if you have requested continuous mode operation (using the **`CM`** channel option) but the sensor does not support continuous mode, or continuous mode has not been enabled on the sensor.

Double check the sensor documentation. It may help to turn on the diagnostic messages, e.g.:

```
P56=2 5SDI12(R207)
5SDI12: [8] 0C2!000000
dataTaker 80 E82 - Serial device data not available (5SDI12:AD0:R207)
5SDI12 NotYetSet
```

In this case the sensor has returned `00000` in response to the *DT80*'s request, indicating that no data values are available in register set #2.

Generic Serial Channel

The *DT80*'s Serial Channel can be used to connect to serial input and/or output devices such as a serial sensor, GPS terminal, printer, barcode reader, display panel, PLC, or even to another *DT80*.

A serial channel

- can transmit programmable 'prompt' or 'poll' messages to serial devices and interpret their replies
- can respond to asynchronous incoming serial messages.
- can operate using the dedicated **serial sensor port** (terminal block connection on front panel; not present on DT81/82E), or the **host RS232 port** (DE9 connector on side panel), or the **USB port**.
- may be included in schedules in the same way as any other *DT80* channel. The channel name **1SERIAL** is used for the serial sensor port, **2SERIAL** for the host port and **3SERIAL** for the USB port.

Connecting to and Configuring the Serial Port

Serial Sensor Port

The serial sensor port is the one most commonly used for defining generic serial channels. It supports RS232, RS422 and RS485 connections.

The default function of this port is **SERIAL** so in that sense it is ready to use as a generic serial channel. You may, however, need to configure the baud rate or other serial parameters to suit the device to which you are connecting.

For more details on setting up the port and the possible wiring configurations, see *Serial Sensor Port* (P171).

Host RS232 Port

The host RS232 port can also be used for controlling serial sensors.

Before a generic serial channel can be defined on this port, the port function must be set to **SERIAL**, as follows:

```
PROFILE HOST_PORT FUNCTION=SERIAL
```

As with the serial sensor port, you may need to change the configured baud rate or other settings.

For more details on setting up the port and the possible wiring configurations, see *Host RS-232 Port* (P170).

USB Port

The USB port may be used in generic serial mode if you need to communicate with a PC application using a custom serial protocol. As with the host port, this requires the port function to be set:

```
PROFILE USB_PORT FUNCTION=SERIAL
```

For more details, see *USB Port* (P162).

Serial Channel Commands

SERIAL Channel Type

Data flow into and out of the a serial channel is controlled by the Serial Channel commands. These commands provide for

- formatting and management of output strings and prompts to be sent to the connected serial device.
- interpretation and parsing of input strings received from the connected device into channel variables
- general management of the Serial Channel

The general form of a Serial Channel command is:

```
nSERIAL("control_string",options)
```

where:

- *n* is the serial port number (**1** for the serial sensor port, **2** for the host port, **3** for the USB port).
- *control_string* is a string of commands that specify the required output and input actions of the Serial Channel. See *The Control String* (P278).
- *options* are any other channel options that may be required

Note that **SERIAL** is actually a channel type, in the same way that **V** (voltage) is a channel type. It can appear in schedules and it has channel options, like any other channel type. The *control_string* is a special channel option which applies only to the **SERIAL** channel type.

Note An error message will be returned if you attempt to define an *n***SERIAL** channel and the selected port's function has

not been set to **SERIAL** in the *DT80* profile.

Channel Options

Most of the standard channel options (*Table 4: DT80 Channel Options* (P43)) may be used with the serial channel, e.g. **W** (working channel), **=nCV** (assign to CV), and so on.

For the **SERIAL** channel type, the **channel factor** is the maximum time to wait for serial data to be received. Default is 10s. This value is a floating point number, so a value of 0.1 will set the timeout to 100ms.

If the standard **"***UserName~UserUnits***"** channel option is specified, it must come after the control string in the list of serial channel options.

Channel Return Value

Depending on the control string, the **return value** of a **SERIAL** channel may be either:

- a data value, interpreted from the data returned by the sensor, or
- a status code, indicating whether the commands in the control string were performed successfully.

See *Return Value* (P283) for more details.

Serial Channel Operation

The Control String

The **"***control_string***"** is always enclosed by quotation marks. It can be broken into two parts:

- **Output actions** — commands, prompts or text strings that are to be sent from the *DT80* to the device connected to the serial channel. The various output actions available are detailed in the section *Control String – Output Actions* (P280). All output actions are enclosed by **{}**.
- **Input actions** — commands to manage the *DT80*'s Serial Channel and to interpret the information coming back from the serial device into the Serial Channel. The various input actions available are detailed in the section *Control String – Input Actions* (P282). Input actions are not enclosed by **{}**.

The general form of the **"***control_string***"** is

- any combination of output actions enclosed by **{}**, and/or
- any combination of input actions.

There may be any number of blocks of output actions and input actions, as shown in the following example Serial Channel commands:

```
1SERIAL("{output actions}",options)
1SERIAL("input actions",options)
1SERIAL("{output actions}input actions",options)
1SERIAL("{output}input{output}input",options)
```

The **"***control_string***"** is always executed in order left to right, giving you complete control over the sequence of actions.

Where a bi-directional dialog occurs between the *DT80* and serial device, the output actions and input actions can be included in the same Serial Channel command as shown above, or in separate Serial Channel commands as follows:

```
BEGIN
 RA1M
  1SERIAL("{output actions}",options)
  1SERIAL("input actions",options)
END
```

This latter approach simplifies the appearance of the program steps for supervising the Serial Channel, particularly if there are a number of data points to be prompted and interpreted or parsed in each access. Note however that each instance of **SERIAL** uses up one channel table entry (see *channel table* (P330))

Serial Data Transmission and Reception

If a job contains one or more **SERIAL** channel definitions then the selected serial ports (host and/or serial sensor) are activated. Data may then be received from a connected serial device at any time whilst the job is loaded. As data is received, it is stored in an area of memory called the serial channel **receive buffer**. A separate receive buffer is maintained for each serial port.

When a **SERIAL** channel is evaluated (i.e. when the schedule of which it is part executes), the *DT80* processes the control string from left to right. Output actions involve data being sent from the *DT80*, so they are performed there and then, as they are encountered in the control string. If the data cannot be sent (e.g. due to flow control) within the timeout period (10 seconds by default) then evaluation of the **SERIAL** channel will be terminated and its status code set to **21** (transmit timeout).

When the *DT80* finds an input action in the control string it will read any previously received data from the receive buffer and attempt to match it against the format specified in the input action. If no data is present in the receive buffer at the time that

the input action is processed then the *DT80* will wait up to 10 seconds (this timeout is configurable) for more data to arrive. Then:

- If the incoming data matches that required by the input action then the *DT80* will move on to the next input action in the string. If the end of the control string is reached then the **SERIAL** channel will return and set its status code to **0** (success).
- If the timeout expires while the *DT80* is waiting for more data then evaluation of the **SERIAL** channel will be terminated and its status code set to **20** (receive timeout).
- If the timeout expires while the *DT80* is waiting for a particular CTS state (i.e. **\c0** or **\c1** input action *(P280)*) then evaluation of the **SERIAL** channel will be terminated and its status code set to **5** (CTS timeout).
- If data is received which violates the input action specification then evaluation of the **SERIAL** channel will be terminated and its status code set to **29** (Scan Error).

Once the **SERIAL** channel has completed and set either a success or failure status code, the *DT80* will then move on to evaluating the next channel (if any) in the schedule.

Depending on how the input actions are specified, the return value of the channel may be either the status code or a scanned data value. See *Return Value* *(P283)*.

The following sections describe in detail the various output and input actions that can be specified in a control string.

Control String – Output Actions

The table below lists the ways in which prompts and text strings can be sent from the *DT80* to the device connected to the Serial Channel. These commands must be enclosed by **{ }** in the control string.

What to output	Output Action syntax	Description
Text	*text* e.g. **abc\009def\013**, **GETVAL^M^J**	A sequence of characters to be **sent**. Non-printable characters may be specified using *****nnn (where *nnn* is the ASCII code, 1-255). **^***char* notation may also be used for control characters (ASCII 1-31), see *ASCII-Decimal* Tables *(P316)*.
Break character	**\b[***n***]** or **\b[***n***CV]**	Transmit a "break" (set the Tx line to logic-0 state) for *n* or *n*CV character periods
Control signal	**\r1**	Set **RTS** (to a value >+3.5V) – RS232 only
	\r0	Clear **RTS** (to a value <–3.5V) – RS232 only
(Wait)	**\w[***n***]** or **\w[***n***CV]**	Delay for *n* or *n*CV milliseconds. Actual delay time will be approximately 2ms or 2 character times, whichever is longer.
reserved characters	**\%** or **\{** or **\}**	Output a **%, {** or **}** character. (**%%** may also be used to output a single **%** character.)
CV value	**%***{flag}{width}.{precision}***type[***n***CV]** e.g. **%d[2CV]** or **%9.3f[7CV]** or **%06d[1CV]**	Output the value of *n*CV in the specified numeric format (see below). Note that *{ }* signifies "optional"
string value	**%***{flag}{width}.{precision}***s[***n***$]** e.g. **%s[1$]** or **%-9.9s[2$]**	Output the value of string variable *n*$

Numeric Formats

This table describes the possible values for *type* – that is, the different ways in which a CV value can be converted into a string of characters.

Type	Description	Example, assumes 1CV = 74.36
f	floating point	**1SERIAL("{%f[1CV]}")** → 74.36
e	floating point, exponential format	**1SERIAL("{%e[1CV]}")** → 7.436e01
E	floating point, exponential format	**1SERIAL("{%E[1CV]}")** → 7.436E01
g	**f** or **e** format depending on value	**1SERIAL("{%g[1CV]}")** → 74.36
G	**f** or **E** format depending on value	**1SERIAL("{%G[1CV]}")** → 74.36
d	integer	**1SERIAL("{%d[1CV]}")** → 74
x	hexadecimal integer	**1SERIAL("{%x[1CV]}")** → 4a
X	hexadecimal integer	**1SERIAL("{%X[1CV]}")** → 4A
o	octal integer	**1SERIAL("{%o[1CV]}")** → 112
c	single character	**1SERIAL("{%c[1CV]}")** → J

Note that

- The **%c** conversion outputs the value of *n*CV as a single 8-bit character. Only the lower 8 bits of the integer portion of *n*CV are output. So in the above example the character value 74 (ASCII "J") will be sent.
- The **%g** and **%G** conversions select exponential notation if the exponent is less than –4, or greater than or equal to the specified

Width, Precision and Flag

The various conversion types described above can be further qualified using the optional *width*, *precision* and *flag* specifiers. These allow you to control exactly how the transmitted data will be formatted.

Field Width

The *width* value specifies the **minimum output field width –** that is, the minimum number of characters that will be output. If the converted value requires fewer characters than the specified field width, then space or zero characters are used to pad the field to the specified width. If the converted value results in *more* characters than the specified field width, then all characters will still be output. The *width* parameter is not applicable for the **%c** conversion type.

The *precision* value means different things depending on the conversion type:

Type	*precision* term specifies:	Default
d, **x**, **X**, **o** (integer)	minimum number of digits to print (leading zeroes will be added if necessary)	no minimum
e, **E**, **f** (floating point)	number of digits to the right of decimal point	6 digits
g, **G** (mixed)	number of **significant digits** shown	6 digits
c (single character)	not applicable	
s (string)	**maximum** number of characters from the string to print	no maximum

Variable Width & Precision

The *width* and *precision* values are normally specified as numeric constants (e.g. **%9.2f**), but they can also be specified as an asterisk (*****), in which case the value of a CV is used instead.

Output Action syntax and example	Description
%{*flag*}*****.{*precision*}***type*** **[***w***CV,***n***CV]** e.g. **%*d[1CV,4CV]** or **%-*.2f[1CV,3CV]**	output the value of *n*CV in the specified numeric format, with the *width* parameter set to the value of *w*CV
%{*flag*}***.*[***w***CV,***p***CV,***n***CV]** e.g. **%*.*g[1CV,4CV,5CV]**	as above, but also set the *precision* parameter to the value of *p*CV

Flag Character

Finally, the *flag* character allows some further options:

Flag	Applicable conversion types	Description
-	**d**, **x**, **X**, **o**, **e**, **E**, **f**, **g**, **G**, **s**	left justify (if spaces need to be added to make up the minimum field width, add them *after* the number rather than before)
+	**d**, **x**, **X**, **o**, **e**, **E**, **f**, **g**, **G**	prefix value with **+** character, if it is positive
(space)	**d**, **x**, **X**, **o**, **e**, **E**, **f**, **g**, **G**	prefix value with space character, if it is positive
0 (zero)	**d**, **x**, **X**, **o**, **e**, **E**, **f**, **g**, **G**	pad the field with leading zero characters (rather than spaces) if required to make up the minimum field width
#	**x**, **X**, **o**	prefix value with **0x**, **0X** or **0**, respectively
#	**e**, **E**, **f**	always include a decimal point
#	**g**, **G**	do not truncate any trailing zeroes after the decimal point

Examples

Examples assume 1CV = 12345.67, 1$ = "pumpkin"	
1SERIAL("{%f[1CV]}")	→ "12345.67"
1SERIAL("{%10f[1CV]}")	→ " 12345.67"
1SERIAL("{%10.1f[1CV]}")	→ " 12345.7"
1SERIAL("{%-10.1f[1CV]}")	→ "12345.7 "
1SERIAL("{%010.1f[1CV]}")	→ "00012345.7"
1SERIAL("{%10.10d[1CV]}")	→ "0000012345"
1SERIAL("{%10.4g[1CV]}")	→ " 1.235e04"
1SERIAL("{%#10.0f[1CV]}")	→ " 12346."
1SERIAL("{%s[1$]}")	→ "pumpkin"
1SERIAL("{%10s[1$]}")	→ " pumpkin"
1SERIAL("{%10.4s[1$]}")	→ " pump"

Control String – Input Actions

The table below lists the commands available to interpret the information coming back into the Serial Channel from the serial device. Input actions are not enclosed by **{ }** in the control string.

Expected data	Input Action syntax	Description
Characters	*text*	For each character in the input action string, the *DT80* will read and discard all incoming characters from the serial device until that particular character is seen. It then discards the matching character and starts looking for the next character in the input action text. For example, if the input action string is **abc** and the input data from the serial device is 3c3aabaAAc123 then all characters up to and including the second "c" will match, i.e. they will be read and discarded. Non-printable characters may be specified using *****nnn (where *nnn* is the ASCII code, 1-255). **^***char* notation may also be used for control characters (ASCII 1-31), see *ASCII-Decimal* Tables *(P316)*. To include a literal **%**, **{** or **}** character, use **\%** or **\{** or **\}** respectively.
Control signal state	**\c1[***n***]** or **\c1[***n***CV]**	wait up to *n* or *n*CV milliseconds for **CTS** input to be set (high) – RS232 only
	\c0[*n***]** or **\c0[***n***CV]**	wait up to *n* or *n*CV milliseconds for **CTS** input to be cleared (low) – RS232 only
(Wait)	**\w[***n***]** or **\w[***n***CV]**	Delay for *n* or *n*CV milliseconds. Actual delay time will be approximately 2ms or 2 character times, whichever is longer.
(Erase receive buffer)	**\e**	Clear all previously received characters from the receive buffer
Fixed text string	**\m[***text***]** or **\m[***n***$]**	Read and discard incoming characters until the exact string *text* (or the text in *n*$) is seen, then discard the matching string
Numeric data	**%***{width}***type***{***[***n***CV]***}* e.g. **%d[2CV]**, **%9f**	Interpret the received data according to the specified numeric format and store the result into *n*CV. If the **[***n***CV]** is not specified, the result will be returned as the return value of the channel. Note that *{ }* signifies "optional"
String data	**%***{width}***type[***n***$]** e.g. **%6s[5$]**	Interpret the received data according to the specified string format and store the result into *n*$
Data to skip	**%*** *{width}***type** e.g. **%*6s**, **%*f**	Interpret the received data according to the specified numeric/string format but do not store the result. In other words, skip over this data value.
One of a set of strings	**%***{width}***type['***str1***','***str2***',...,***n***CV***{=***m***}***]** e.g. **%9s['goose','moose',23CV=2]**	If the incoming string matches *str1* then set *n*CV=0 If the incoming string matches *str2* then set *n*CV=1 If the incoming string matches *str3* then set *n*CV=2 (etc.) If a default value (**=***m*) is specified and the incoming string matches none of the strings then set *n*CV=*m*

Numeric and String Formats

These tables describe the possible values for *type* – that is, the different ways in which the incoming string of characters can be interpreted.

Type	Description	Example, assumes input data string is 123.456
f	floating point	**1SERIAL("%f[1CV]")** → 1CV = 123.456 (nothing left in receive buffer)
d	decimal integer	**1SERIAL("%d[1CV]")** → 1CV = 123 (.456 left in receive buffer)
x	hexadecimal integer	**1SERIAL("%x[1CV]")** → 1CV = 291 (.456 left in receive buffer)
o	octal integer	**1SERIAL("%o[1CV]")** → 1CV = 73 (.456 left in receive buffer)
i	decimal/hex/octal integer	**1SERIAL("%i[1CV]")** → 1CV = 123 (.456 left in receive buffer)
c	character	**1SERIAL("%c[1CV]")** → 1CV = 49 (23.456 left in receive buffer)
b	binary (no conversion)	**1SERIAL("%b[1CV]")** → 1CV = 49 (23.456 left in receive buffer)

Type	Description	Example, assumes input data string is aaba cxyab↵
s	string (↵ terminated)	**1SERIAL("%s[1$]")** → 1$ = "aaba cxyab" (nothing left in receive buffer)
S	string (whitespace terminated)	**1SERIAL("%S[1$]")** → 1$ = "aaba" (cxyab↵ left in receive buffer)
[*chars***]**	string containing only specified chars	**1SERIAL("%[abc][1$]")** → 1$ = "aaba c" (xyab↵ left in receive buffer)
[~*chars***]**	string not containing specified chars	**1SERIAL("%[~bc][1$]")** → 1$ = "aa" (ba cxyab↵ left in receive buffer)

- Conversions which may be terminated by whitespace *(P338)* (**%f**, **%d**, **%x**, **%o**, **%i** and **%S**) will skip over any leading whitespace, e.g. **%d** will match input strings of "123", " 123" and " \013\013\010 123".
- The **%i** conversion assumes that the value is hexadecimal if it starts with 0x or 0X, octal if it starts with 0 (zero), otherwise decimal.
- The **%f** conversion will accept numbers in standard (e.g. -12.39904) or exponential (e.g. -1.239904e01) format.
- The **%c** and **%b** conversions treat the characters as 8-bit binary values. So the character "1" (ASCII 49) will result in the value 49 being stored in the CV.

Return Value

The **return value** of a **SERIAL** channel may be either a status code or a data value:

- If all numeric input conversions in the control string include a **[***n***CV]** specification then the **SERIAL** channel will return the status code – 0 (success), 20 (receive timeout), 21 (transmit timeout), 5 (CTS timeout) or 29 (scan error); see *Serial Data Transmission and Reception* *(P278)*
- If one or more numeric input conversions in the control string do not include a **[***n***CV]** specification then the **SERIAL** channel will return the result of the rightmost conversion. If any part of the channel's evaluation fail (i.e. the channel's status code is non zero) then the returned value will be the special "Not Yet Set" error value.

The following example will attempt to read a floating point value from the serial sensor and return the value read

```
RA2+E 1SERIAL("%f")
1SERIAL 27.9

1SERIAL 31.2

dataTaker 80 E89 - Serial sensor receive time out
1SERIAL NotYetSet
```

Compare this with the following example, which instead assigns the value to a CV:

```
RA2+E 1SERIAL("%f[1CV]") 1CV
1SERIAL 0 State
1CV 27.9

1SERIAL 0 State
1CV 31.2

dataTaker 80 E89 - Serial sensor receive time out
1SERIAL 20 State
1CV 31.2
```

For many applications the form where the **SERIAL** channel returns the actual value scanned provides a simpler solution.

Width

The optional *width* value specifies the maximum number of characters to read for conversion. For example, with the above example's input data: **1SERIAL("%2d[1CV]")** will result in 1CV = 12 (3.456 left in receive buffer). The default for most of the conversions (except **%c** and **%b**) is to keep reading characters until an invalid character is read. (That's why the integer conversions in the above example stop when the "." character is seen.)

The default *width* value for **%c** and **%b** is 1; with this setting the two conversions behave identically. However, if *width* is specified then:

- for **%c**, only the last character is read; preceding characters are skipped
- for **%b**, the specified number of characters are treated as a multi-byte binary word, in "big-endian" (most significant byte first) format. Note that due to the limited precision of CVs, the maximum practical width value is 3 (24 bits).

For example:

Example assumes input data is `123.456`
`1SERIAL("%1c[1CV]")` → 1CV = 49 (`23.456` left in receive buffer)
`1SERIAL("%2c[1CV]")` → 1CV = 50 (`3.456` left in receive buffer)
`1SERIAL("%3c[1CV]")` → 1CV = 51 (`.456` left in receive buffer)
`1SERIAL("%1b[1CV]")` → 1CV = 49 (`23.456` left in receive buffer)
`1SERIAL("%2b[1CV]")` → 1CV = 12594 (49*256 + 50) (`3.456` left in receive buffer)
`1SERIAL("%3b[1CV]")` → 1CV = 3223859 (49*65536 + 50*256 + 51) (`.456` left in receive buffer)

Important If *width* is not specified then the incoming data must be terminated by a non-matching character, otherwise the serial channel will continue to wait for more characters to be read, eventually returning a timeout.

For example, if the control string is `1SERIAL("%d")`:

Input data	Result
"`abc`"	Scan Error (return `NotYetSet`; `abc` left in receive buffer)
"`123`"	Receive Timeout (return `NotYetSet`, nothing left in receive buffer)
"`123 `"	return 123 (" " left in receive buffer)
"`123abc`"	return 123 (`abc` left in receive buffer)

Control String – Example

The control string in the Serial Channel command

```
1SERIAL("\e{WN\013}%d[1CV],%f[2CV]{C\013}\w[2000]")
```

specifies the following output and input actions for supervising electronic weighing scales connected to the serial sensor port of a *DT80*:

Input/Output action	Description
`\e`	An input action. `\e` erases any extraneous characters that may have been sent by the scales at some earlier time.
`{WN\013}`	An output action. Sends the "Weigh Now" command (`WN`) to the scales. The `WN` command is terminated by a carriage return (`\013`). (See your serial device's manual for details of its command set.)
`%d[1CV],%f[2CV]`	Three input actions. These scales return two comma-separated values: a batch number as an integer, and the weight as a floating-point value, followed by a carriage return. • `%d[1CV]` will interpret the first returned value as an integer batch number, and assign this to 1CV. • Skip the comma in the returned data string (`,`). • `%f[2CV]` will interpret the second returned value as a floating-point weight in kilograms, and assign this to 2CV.
`{C\013}`	An output action. These scales also have a Clear command (`C`), which instructs the scales to clear ready for the next weighing operation.. This output action sends the Clear command to the scales. The Clear command is terminated by a carriage return (`\013`).
`\w[2000]`	An input action. These scales do not respond to commands for 2s after a Clear operation. The `\w[2000]` action ensures that at least this time elapses following a Clear.

Important The ***DeTransfer*** program, which is often used to supervise the *DT80*, has a number of special commands that begin with a `\` (backslash) character. These are interpreted by *DeTransfer* and not sent to the *DT80*. In order to send a `\` character from *DeTransfer*, you need to enter a double backslash (`\\`). For example, the above example would be entered into *DeTransfer* as follows:

```
1SERIAL("\\e{WN\\013}%d[1CV],%f[2CV]{C\\013}\\w[2000]")
```

This rule applies to *DeTransfer* only; it does not apply to the "Text" window in *DeLogger*, for example.

Schedules

Executing Serial Channel Commands in Schedules

Like any other channel type, Serial Channel commands can be placed into scan schedules. For example

```
BEGIN
PS=RS485,9600
RA1M 1SERIAL("\e{01READ^M}%6f")
RB2-E 1SERIAL("\e{02READ^M}%12s[1$]",W) 1$
LOGON
END
```

This example will, once a minute, request then read a floating point value from device #1 on the multi-drop RS485 link connected to the serial channel. Also, every time digital input **2D** goes low, the serial channel will request then read a string value from device #2.

Notice that in the first schedule the scanned floating point value is the return value of the **SERIAL** channel, which will then be logged and returned. In the second schedule, the scanned string is assigned to string variable 1$. The **SERIAL** channel will then return a status code – which in this example we are not concerned about so the **W** channel option is used to make the channel a working channel (not logged or returned).

Serial commands can also be used in the "immediate" schedule, i.e. executed immediately after they are entered. For example, sending

```
2SERIAL("{hello^M^J}")
```

will immediately transmit the indicated string on the host port (assuming it has been configured for serial channel operation).

Triggering Schedules

Sometimes the serial device connected to the Serial Channel returns data unsolicited, and so the program must be capable of responding to the device at any time. As discussed in *Trigger on External Event* *(P48)*, any schedule (**R***a*) can be defined to trigger on the receipt of the specified string on the Serial Channel as follows:

```
RanSERIAL"text"
```

where *a* is the schedule identifier (A-K, X) and *n* is the serial channel port number (1 or 2)

The text string may also be blank:

```
RanSERIAL""
```

in which case any character received into the Serial Channel produces a trigger.

Whenever the Serial Channel produces a trigger by either of these methods, the receive buffer will contain the string that caused the trigger, ready to be processed by an *n***SERIAL** command.

In the following example a serial device transmits whitespace separated temperature readings at irregular intervals. The following job will read and log readings when they are received:

```
BEGIN
RA1SERIAL""  1SERIAL("%f","SS Temp~degC")
LOGON
END
```

Note that the **1SERIAL***"text"* schedule trigger does not consume (i.e. remove from the receive buffer) any received characters that did not match *text*. This means that there may be other characters in the receive buffer preceding the *text* string. An input action should therefore normally be included to discard any characters that do not match *text*. For example:

```
RA1SERIAL"abc:" 1SERIAL("\m[abc:]%f")
```

which will read and discard characters until the exact string `abc:` is seen.

Re-triggering

The *DT80* checks any serial schedule triggers:

- on receipt of data on the serial sensor port, and
- following execution of any schedule containing an *n***SERIAL** channel.

This means that if multiple messages are received in quick succession then all will be processed in turn. For example, suppose the following schedule is entered:

```
RA1SERIAL"x:" 1SERIAL("\m[x:]%d")
```

and then the following serial data string is received:

```
x:1298 x:1265 x:0772
```

Receipt of this data will trigger the A schedule, and the **1SERIAL** channel will then parse the first value, leaving " `x:1265 x:0772` " in the receive buffer. This string still matches the schedule trigger (i.e. it contains "`x:`"), so the A schedule will be immediately re-triggered.

Serial Sensor Direct Mode

It is sometimes necessary to interactively set up or test a serial sensor device. This can be done without disconnecting the device from the serial port using the *DT80*'s **serial sensor direct** mode.

The following command:

SSDIRECT *n*

causes the communications port on which the command was sent (host port, USB, TCP/IP) to enter SSDIRECT mode.

Whilst in this mode:

- all subsequent commands that you enter on that port will not be processed by the *DT80* and will instead be transmitted out the specified serial channel port – the serial sensor port if *n* = 1 (which is the default), or the host port if *n* = 2, or the USB port if *n* = 3. The one exception is **ENDSSDIRECT**, which is used to cancel SSDIRECT mode.
- all data received from the specified serial channel port will be returned to the host PC via the comms port that is in SSDIRECT mode.
- all transmit data (i.e. output actions) generated by the evaluation of *n***SERIAL** channels will be discarded.
- all normal output data from the logger (e.g. real time data, status and error messages, etc) will not be returned to the SSDIRECT-mode comms port. It will still be returned to any connected TCP/IP ports (see *Broadcasting Data* (P161)), or to another comms port if you make it the active comms port by sending a command to it.

Serial sensor direct mode remains in effect until the **ENDSSDIRECT** command is received. The **ENDSSDIRECT** command may be issued on the SSDIRECT-mode comms port, or on any other comms port.

Only one communications port can be in SSDIRECT mode at any one time. So if you send **SSDIRECT** via the USB port (thereby setting that port to SSDIRECT mode), then send another **SSDIRECT** command via a TCP/IP (Ethernet) connection, then an error message will be returned and the second **SSDIRECT** command will be ignored. In order to establish SSDIRECT mode on the TCP/IP connection it would be necessary to first send the **ENDSSDIRECT** command.

Line Termination

By default, each line of text entered in SSDIRECT mode will be terminated by a single CR character when sent to the specified serial channel port. This behaviour can be changed by specifying a second parameter in the **SSDIRECT** command, which indicates the terminating string to add to the end of each line. For example:

- **SSDIRECT 1 "^M"** – terminate each line with a CR character (default)
- **SSDIRECT 1 "^M^J"** – terminate each line with CR LF
- **SSDIRECT 1 ""** – do not add any termination

Example

For example, if a *dataTaker CANgate* (CAN bus to ASCII gateway) was connected to the serial sensor port then the following dialog would be possible:

```
1V 9.22 mV

1V 10.09 mV

SSDIRECT
SSDIRECT mode active. Issue ENDSSDIRECT to quit
VERSION
dataTaker CANgate Version 1.24
SNOOPJ 2
EXT  0CF00400 FE7D7D000000FFFF  PGN:61444 PRI:3 SA:0 DA:0
EXT  18FEF000 FFFFFF0000F0CCFF  PGN:65264 PRI:6 SA:0 DA:0
EXT  18F0000F C07DFFFF0FFFFFFF  PGN:61440 PRI:6 SA:15 DA:0
END SNOOP
ENDSSDIRECT
SSDIRECT mode deactivated.

1V 7.12 mV
```

In this example, the regular real time data returns for channel 1V are suspended when **SSDIRECT** is entered. The next two commands that were entered (**VERSION** and **SNOOPJ**) are *CANgate* commands, not *DT80* commands. The *DT80* passes them directly through to the *CANgate*. In each case, the *CANgate* returns some information, which the *DT80* then passes on to the host computer without modification.

When **ENDSSDIRECT** is entered the *DT80* returns to normal operation and the real time data returns resume.

Serial Interface Power Control

If the current job contains no **1SERIAL** commands then the serial channel interface is automatically switched off, which saves a small amount of power. If the current job does contain **1SERIAL** commands then serial channel will be continuously powered.

The **1SSPORT** channel type allows you to turn power to the interface on and off under program control e.g.

```
RA1H 1SSPORT=1 1SERIAL("\w[1000]{X}%d") 1SSPORT=0
```

will, once an hour, switch on the serial channel, poll and read an integer from a serial device, then switch off the serial channel.

Serial Channel Debugging Tools

P56 Debugging

Setting **P56=1** will cause the *DT80* to output a number of **diagnostic messages**, which are useful when setting up and testing a serial channel application – or trying to figure out why it doesn't appear to be working as expected.

The following information will be returned:

- each string of output actions, and each individual input action, as they are processed
- (indented 1 space) actual transmitted data and other transmit operations e.g. breaks, delays as they are performed
- (indented 2 spaces) the state of the receive buffer each time something is added (i.e. received), each time something is removed (i.e. an input action matches) and the initial state – these are denoted RxBuf+, RxBuf- and RxBuf= respectively – also any schedules that are triggered by received characters. The number after the +, - or = character indicates the number of characters in the buffer.

Using the weighing machine example discussed earlier:

```
P56=1
RA1-E 1SERIAL("\e{WN\013}%d[1CV],%f[2CV]{C\013}\w[2000]")
1SERIAL:   RxBuf=0[]
1SERIAL: InputAction: "\e"
1SERIAL: OutputActions: "WN\013"
1SERIAL:  Tx [WN\013]
1SERIAL: InputAction: "%d[1CV]"
1SERIAL:   RxBuf+12[0242,1.988\013\010]
1SERIAL:   RxBuf-8[,1.988\013\010]
1SERIAL: InputAction: ","
1SERIAL:   RxBuf-7[1.988\013\010]
1SERIAL: InputAction: "%f[2CV]"
1SERIAL:   RxBuf-2[\013\010]
1SERIAL: OutputActions: "C\013"
1SERIAL:  Tx [C\013]
1SERIAL: InputAction: "\w[2000]"
1SERIAL:  Wait (2000ms)
1SERIAL 0 State

1SERIAL:   RxBuf=2[\013\010]
1SERIAL: InputAction: "\e"
1SERIAL:   RxBuf-0[]
1SERIAL: OutputActions: "WN\013"
1SERIAL:  Tx [WN\013]
(etc.)
```

In this case you can see that the weighing machine returned the batch number, weight and terminating CR/LF in one 12-character burst (RxBuf+12[0242,1.988\013\010]). The various input actions then dissected this string, removing first the batch number, then the comma, then the weight. At the end of the process the CR/LF was still in the buffer, and it was still there when the next measurement cycle began (RxBuf=2[\013\010]). It was then cleared by the **\e** input action.

Serial Loopback

A useful technique for testing your parsing commands is to implement a serial loopback in the RS-232 mode. Simply connect the **Tx/Z** and **Rx/A** terminals together, and then send strings out of the Serial Channel by output actions. Because of the loopback, these strings appear in the receive buffer, which can then be parsed by your input actions. The strings you should send should contain data formatted in the same way that the real sensor would. In this way you are simulating the sensor for the purposes of verifying that your program can correctly interpret what it needs.

For example, if a loopback connection is used, the commands

```
1SERIAL("\e{ABCD,1234\013}%4s[1$],%4d[1CV]") 1$ 1CV
```

should store ABCD into 1$ and 1234 into 1CV.

Serial Channel Examples

Reading Variable Width ASCII

In this example a sensor with an RS232 interface will, in response to a **M** followed by a CR, transmit an integer status code (which we ignore), followed by four whitespace-separated floating point pressure values. This job reads and logs these values every 5 minutes:

```
BEGIN"LUCY"
PS=RS232,9600
RA5M
 1SERIAL("{\eM^M}%*d%f[1CV]%f[2CV]%f[3CV]%f[4CV]",W)
 1..4CV("~kPa")
LOGON
END
```

Reading Fixed Width ASCII

In this case a simple serial sensor continuously transmits a stream of records which consist of an `A` character followed by four 4-digit fixed point (2 decimal place) temperature values (`2209` represents 22.09, for example).

This job samples the stream every 30 seconds and logs the values it reads.

```
BEGIN"SPOT"
PS=RS232,1200,7,E,1
RA30S
 1SERIAL("\eA%4d[1CV]%4d[2CV]%4d[3CV]%4d[4CV]",W)
 1..4CV(.01,"~degC",FF2)
LOGON
END
```

Notice that the receive buffer is cleared at the start of the control string. The **1SERIAL** channel will therefore wait until the next update from the sensor. An alternative strategy would be clear the buffer at the end, in which case the **1SERIAL** channel would immediately get what it needs from the buffer. However the data it reads will be the first record in the buffer and would therefore be up to 30s old.

Reading Binary Data

In this example an even more simple sensor outputs 6 bytes of data in response to a digital signal going low. These are to be interpreted as two binary values. The first is a 16-bit integer sequence number, in big endian format (most significant byte first). The second value is a 32-bit voltage measurement, scaled such that 0x00000000 represents -17.0V and 0xFFFFFFFF represents +17.0V. For historical reasons, this value happens to be returned in little-endian (least significant byte first) format.

This job triggers a reading (by pulsing the **1D** output low) every 5 seconds and reads and logs the received values.

```
BEGIN"RAMBUTAN"
PS=RS232,115200
S1=-17,17,0,4294967296"V"
RA5S
 1DSO(100,R)=0
 1CV(W)=-1
 1SERIAL("%2b[1CV]%b[5CV]%b[6CV]%b[7CV]%b[8CV]",W)
 1CV("Seq")
 2CV(S1)=8CV*16777216+7CV*65536+6CV*256+5CV
LOGON
END
```

Note the following points about this job:

- In this case the sequence number can be read as a single binary number, using **%2b**, but the measured value must be read byte by byte and reassembled into a single value.
- A span (**S1**) is used to scale the reading into the correct range.
- 1CV is set to an error value (-1) before each attempt to read the serial channel. If the attempt fails (e.g. no data is forthcoming from the device) then 1CV will be unchanged, so the value -1 will be logged for the sequence number. This makes it easy to identify the reading as invalid.

Note CVs can only precisely store integers with absolute value less than 16,777,216 (24 bits) – above that they will be rounded. In the above example this is not a problem because the value is scaled and rounded anyway.

If, however, you need to recover all 32 bits exactly (for example if they represented 32 separate logic states) then you should read them using two 16 bit conversions and log each half separately, e.g.:

```
BEGIN"WHISTLE"
RA1+E
 1..2CV(W)=-1
 1SERIAL("%2b[1CV]%2b[2CV]",W)
 1CV("MS 16 bits") 2CV("LS 16 bits")
LOGON
END
```

(This example assumes the data word is in big endian format.)

Output to Serial Printer/Display

The serial channel can also be used to output selected channels to a serial printer or display. This job will measure two

voltages once a minute and print the values to a serial printer:

```
BEGIN"SOUP"
RA1M
 1V(W,=1CV) 2V(W,=2CV)
 1SERIAL("{%9.3f[1CV] mV  %9.3f[2CV] mV^M^J}",W)
END
```

Output to Another *DT80*

You can also connect a the serial channel to the RS232 host port on a second *DT80* (or other *dataTaker* model).

The following job will send commands to a second logger to read two immediate channels, then interpret its fixed format response, which will be similar to:

```
D,000043,"",2006/02/13,18:16:54,0.191528,0;*,0,22.2172,-12.2002;0063;F2F3
```

```
BEGIN"LAMBDA"
PS=RS232,57600
RA30S
 1..2CV(W)=-999
 1SERIAL("\e{/H/R 1*TK 1+TK^M}\m[,0;*,0,]%f[1CV],%f[2CV]",W)
 1..2CV("~degC")
LOGON
END
```

In this case we first send **/H/R** to ensure that the other logger is in fixed format mode and has data returns enabled, then the three immediate channel definitions. When parsing the response, we look for the exact string ",0;*,0," followed immediately by two comma separated floating point values.

Schedule Triggering (1)

In this example a barcode reader transmits a packet consisting of an STX character (ASCII 01) followed by a 7 digit ASCII integer. Once a valid barcode packet is received, the job will measure three voltages and log these, along with the barcode.

```
BEGIN"ZAMBESI"
PS=RS232,9600
RA1SERIAL"\001"
 1SERIAL("\001%7d") 'read and log barcode
 1..3V              'log voltages
LOGON
END
```

Schedule Triggering (2)

In this example a GPS unit produces an NMEA 183 data stream, e.g.:

```
$GPGLL,4250.5589,S,14718.5084,E,092204.999,A*2D
```

This job will read and log the latitude degrees (positive for north), latitude minutes, longitude degrees (positive for east) and longitude minutes. Each read is triggered by the $GPGLL header at the start of each transmission.

```
BEGIN
PS=RS232,38400
RA1SERIAL"$GPGLL"
 1SERIAL(",%2d[1CV]%f[2CV],%c[3CV],%3d[4CV]%f[5CV],%c[6CV]",2,W)
 IF(3CV><82.5,83.5){1CV=-1CV}  ' S = ASCII 83
 IF(6CV><86.5,87.5){4CV=-4CV}  ' W = ASCII 87
 1CV("Lat deg",FF0) 2CV("Lat mins",FF4)
 4CV("Long deg",FF0) 5CV("Long mins",FF4)
END
```

Note Remember that if *DeTransfer* is used to send commands then two backslash characters must be sent each time a backslash is required. (see *Control String – Example* *(P284)*)

Modbus Channel

Not available on DT81/82E

About Modbus

Modbus is a simple communications protocol which is widely used in **SCADA** (supervisory control and data acquisition) systems. Modbus provides an efficient and standardised way to transport digital states and data values between a remote terminal unit (**RTU**) or programmable logic controller (**PLC**) and a supervisory computer.

Servers and Clients

In a Modbus-based SCADA system, each RTU/PLC acts as a Modbus **server**, or **slave**. These servers/slaves listen for and reply to requests from a Modbus **client**, or **master** system.

As described in *Modbus Interface* *(P151)*, the *DT80* is capable of operating as a Modbus server; that is, it can act like an RTU or PLC device, and make data available when polled by a client system.

The *DT80* can also operate as a Modbus client, where it can read data from Modbus sensors in the same way that it reads data from SDI-12 or serial sensors.

The remainder of this section describes the operation of the *DT80* as a Modbus client.

The MODBUS Channel Type

To read data from a Modbus device (or write control information to it), the **MODBUS** channel type is used. Each time a **MODBUS** channel is evaluated, the *DT80* will send a Modbus request to the device, retrieve the response, extract the required data and return it so that it can be displayed or logged in the usual way.

Modbus can operate using a broad range of communications media. These fall into two main categories:

- a serial connection, typically RS232, RS422 or RS485
- a TCP/IP network, which can use a variety of physical link types e.g. Ethernet, wireless, fibre-optic, serial (PPP)

As with the **SERIAL** and **SDI12** channel types, for Modbus channels the channel number refers to the physical *DT80* port to which the sensor is wired. That is:

- **1MODBUS** is used to read sensors connected to the serial sensor port
- **2MODBUS** is used to read sensors connected to the host RS232 port
- **3MODBUS** is used to read sensors connected to the USB port
- **4MODBUS** is used to read sensors connected to a TCP/IP network.

Connecting Serial Modbus Sensors

A serial Modbus network has one client (master) system – in this case, the *DT80* – connected to one or more server (slave) devices. Serial networks using the RS485 or RS422 standards support multi-drop, i.e. multiple slaves connected to one master. RS232 or USB can also be used for point-to-point connections (single master and single slave).

Slave devices on a serial Modbus network are identified by an 8-bit **slave address** (1-247). Every slave device on a particular serial network must have a unique address. (Slave addresses are not required on a TCP/IP Modbus network, because the slaves are identified by their IP address.)

The *DT80* can be connected to a serial Modbus network using either the serial sensor port, the host RS232 port, or the USB port.

Note that if a particular serial port is set up to read Modbus sensors then that port must be dedicated to that function. It cannot also be used for controlling generic serial devices or sending commands to the logger's command interface.

Serial Sensor Port

The serial sensor port is the one most commonly used for connecting serial Modbus sensors. It supports RS232, RS422 and RS485 connections. Note however that the serial sensor port is not available on the DT81/82E.

To configure the serial sensor port for Modbus master operation, set the following profile:

```
PROFILE SERSEN_PORT FUNCTION=MODBUS_MASTER
```

If you try to define a **1MODBUS** channel without setting this profile then an error message will be returned.

For more details on setting up the port and the possible wiring configurations, see *Serial Sensor Port* *(P171)*.

Host RS232 Port

The host RS232 port can also be used for controlling a Modbus sensor. This is configured in a similar way:

```
PROFILE HOST_PORT FUNCTION=MODBUS_MASTER
```

Note that because RS232 is a point-to-point connection, only one Modbus device can be connected to this port.

As with the serial sensor port, you may need to change the configured baud rate or other settings. For more details on setting up the port and the possible wiring configurations, see *Host RS-232 Port* (P170).

USB Port

The USB port may also be used for polling a Modbus sensor. Such a "sensor" would generally be a PC-based system, as a stand-alone sensor would most likely have the wrong type of USB interface and would not be able to connect to the *DT80*'s USB port.

To configure the *DT80* USB port for Modbus master operation use:

```
PROFILE USB_PORT FUNCTION=MODBUS_MASTER
```

For more details, see *USB Port* (P162).

Connecting Network Modbus Sensors

A network Modbus sensor communicates with a client system such as the *DT80* using a TCP/IP network. This network may use a variety of different physical link types, including Ethernet, serial links, wireless and optical fibre. Normally, the *DT80*'s Ethernet port is used to connect to a TCP/IP network, and in most cases the sensor will also connect using an Ethernet port.

In order to communicate over a TCP/IP network, all devices connected to that network are required to have a unique **IP address**. So in order for the *DT80* to be able to poll network Modbus sensors, the *DT80* must have an IP address and so must each sensor.

See *Ethernet Communications* (P179) for more details about IP addresses and how to assign one to the *DT80*.

There are many different ways in which network Modbus sensors can be connected to the *DT80*. The simplest possible network is a single cross-over cable between the sensor and the *DT80*'s Ethernet port.

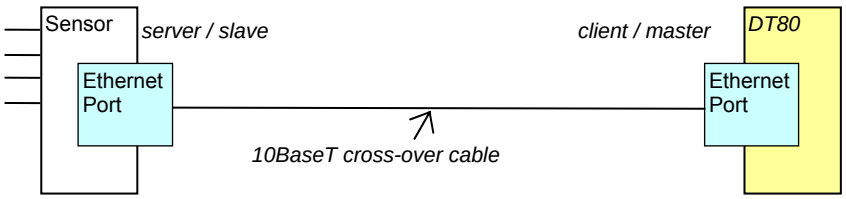


Figure 129: Direct Ethernet connection between DT80 *and a network Modbus sensor*

More typically, the *DT80*'s Ethernet port would be connected to an existing Ethernet network, which may have several Modbus devices attached. There may even be devices connected via the Internet.

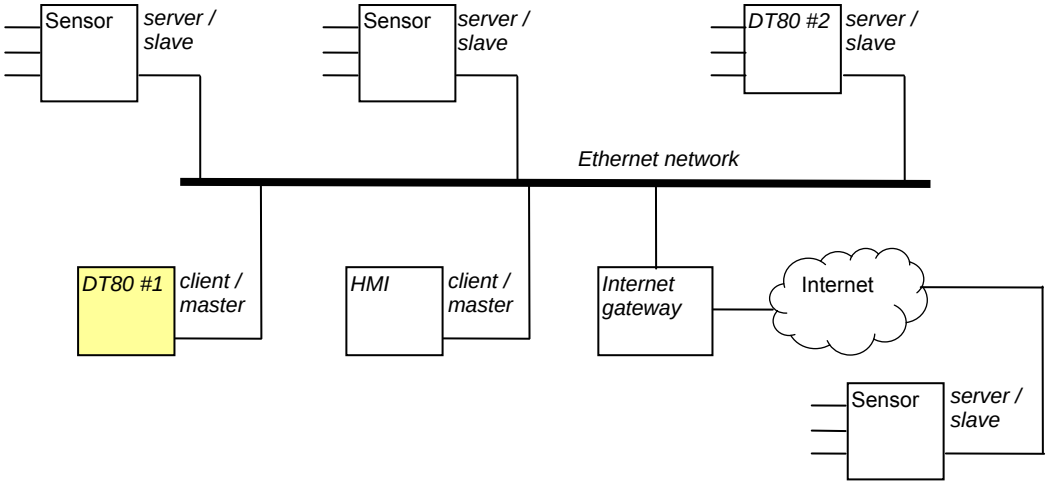


Figure 130: One possible Modbus network configuration

For example, *Figure 130* shows one possible network configuration. In this example, three network Modbus sensor devices are used. Two are connected to the local Ethernet network, and one is remote, accessed via the Internet. DT80 #2 is also set up as a network Modbus sensor, as described in *Modbus Interface* (P151). All of these devices operate as Modbus server, or slave, devices.

DT80 #1 is set up as a Modbus client, or master, device. It has no physical sensors of its own connected (although it could have); its job here is to retrieve measurements from the four slave devices and log them. There also happens to be a Modbus HMI (Human-Machine Interface) device connected. This is also a client/master device, which, like DT80 #1, regularly scans the sensors. It then presents this data as a mimic display. Unlike a serial Modbus network, there is no problem having multiple master devices on a TCP/IP Modbus network.

There is no particular configuration required to enable the *DT80* to operate as a Modbus client. Unlike a serial Modbus network, with TCP/IP many different protocols can be used on the network at the same time so there is no need to set the "function" of the Ethernet port. However, some configuration of the *DT80* may be required in order for the *DT80* to be able to "see" the various Modbus server devices. Depending on how the network is set up, you may need to set:

- *DT80* IP address (**PROFILE ETHERNET IP_ADDRESS=**...)
- subnet mask (**PROFILE ETHERNET SUBNET_MASK=**...)
- gateway address (**PROFILE ETHERNET GATEWAY=**...)
- DNS server address (**PROFILE NETWORK DNS_SERVER_1=**...)

You may also need to configure the Modbus sensor devices themselves.

Reading Data from Modbus Devices

Modbus Registers

As described in *The Modbus Data Model* *(P152)*, a Modbus slave device makes available the following resources:

- an array of single bit **coils** (digital outputs), numbered from 0:00001 to 0:65536.
- an array of single bit **discrete inputs** (digital inputs), numbered 1:00001 to 1:65536
- an array of 16-bit **input registers**, numbered 3:00001 to 3:65536
- an array of 16-bit **output registers** (a.k.a **holding registers**), numbered 4:00001 to 4:65536

As can be seen, the first digit of the register number indicates the type of register – 0, 1, 3 or 4 for coil, discrete input, input register or output register respectively. This usage is, however, just a convention. This digit is not part of the actual address transmitted in the Modbus message.

The documentation for the slave device will describe the function of each register. Bear in mind, however, that there are a few different ways of specifying Modbus register numbers:

- 6-digit notation, as used in this manual. The first digit specifies the type of register, then there are five decimal digits to specify the register number (00001-65536). In this manual, a colon (:) is used to separate the register type and number. In reading Modbus device documentation you may also see an 'x' character used, or no separator at all.
- 5-digit notation. This is similar except that only four digits are used for the register number (0001-9999)
- protocol address. This is a decimal number 0-65535 or hexadecimal 0000-FFFF. The type of register would need to be indicated in the text accompanying the register listing.

For example, "3:00043", "3x00043", "30043" and "input register address 42 (002Ah)" are all different ways of referring to the same input register.

Interpreting Register Values

The Modbus protocol is just a way of transporting 16-bit (or 1-bit) values from A to B. It is up to the master and slave devices to agree on how these values are to be interpreted.

By default, each register is normally taken to hold an independent signed integer value in the range -32768 to 32767. For many applications this range is quite adequate, especially if a fixed scaling factor is also applied (for example a device may return a temperature in tenths of a degree).

However, various schemes have been developed in order to allow higher precision values to be returned via Modbus. These involve joining adjacent registers together to allow 32-bit values to be returned. These 32-bit quantities may then be interpreted as long integers or floating point values.

The *DT80* provides options to support many of these methods. It should be stressed however that sending 32-bit quantities over Modbus is not standardised, so you will need to carefully match the *DT80*'s settings with the specific device that you wish to read.

Using the MODBUS Channel

To poll a Modbus slave device, you use the *n***MODBUS** channel type. As mentioned above, the *n* specifies the physical *DT80* port: 1, 2 or 3 for a serial Modbus connection via the serial sensor port, host RS232 port or USB port respectively, or 4 for network Modbus over TCP/IP (generally using the Ethernet port).

To read a single value, you simply define a **MODBUS** channel and specify appropriate channel options, as described below. This definition is placed in a schedule, as you would for any other *DT80* channel type.

When the channel is executed, the *DT80* will send a "read" request to the specified device, wait for its response, do any requested scaling or statistics on the returned value, then log or return the final reading.

To write a value, an expression is specified, as you would when setting a channel variable. For example,

```
1MODBUS(...)=1CV*2
```

will set the required register on the required Modbus slave device (as specified in the channel options) to the value of 1CV multiplied by 2.

Note If the value being written is outside the range of the target Modbus register then it will be set to the registers minimum or maximum value, e.g.

```
4MODBUS(AD"10.23.0.4",R4:7)=239999
4MODBUS 65535
```

MODBUS Channel Options

Channel options are used to specify

- which Modbus sensor to access, i.e. its network address
- which register(s) to access
- how to interpret the register value (signed or unsigned? 16 or 32 bit?)
- how to scale the result into the correct engineering units
- communications options such as timeouts

Of these, the first two (sensor address and register number) will normally always need to be specified. The remainder are optional and the default values will be appropriate for many applications.

Address (AD)

For serial Modbus (**1**/**2**/**3MODBUS**), the slave device address is specified using the **AD***n* option, where *n* is the numeric slave address (1-247). Address 0 can also be used, which will broadcast a write command to all connected slave devices. Slave devices never reply to a broadcast request.

For network Modbus (**4MODBUS**), use **AD"***ip-addr***"**, where *ip-addr* is either a numeric address (eg. **192.168.11.160**) or a symbolic address (e.g. **myplc.llamas.org**). The address can optionally be suffixed by a port number e.g. **AD"192.168.1.2:5555"** if the default port (502) is not suitable.

Note that symbolic addresses are resolved when the channel is defined (i.e. when the program is started), not when the channel is evaluated. Using slave devices with dynamically allocated IP addresses are therefore not recommended, as an error will result if the IP address changes during operation.

Register (R)

To specify the register number to read/write, use the **R***type***:***num* channel option. That is, the register number is specified using the "6-digit" notation with a colon (**:**) separator between the register type (0/1/3/4) and the register number (1-65536).

For example, **R3:27** specifies the device's 27th input register. (At the protocol level, the *DT80* would send a "read register" command and specify address 26, or 001A.)

A complete channel definition would therefore be something like:

```
1MODBUS(AD2,R3:27)
```

which will read register 1:00027 (input register #27) on the device with address 2 connected to the *DT80* serial sensor port.

For 1-bit Modbus registers, i.e. coils (type 0) and discrete inputs (type 1), it is also possible to read/write up to 16 bits at once. This is done by adding an extra field onto the end of the **R** channel option to specify the number of consecutive 1-bit registers to pack into one value. The full syntax for this option is therefore **R***type***:***num***:***bits*, where *bits* is a number between 1 and 16 (default 1). The **:***bits* part is only valid if a 1-bit register type is specified, i.e. *type* is 0 or 1.

For example, **R1:64** will read discrete input #64 and return its value (0 or 1). On the other hand, **R1:64:8** will read discrete inputs #64 through #71 and return them as an 8-bit bitmask (0 to 255). Input #64 will be the least significant bit (bit 0), input #71 will be the most significant bit (bit 7).

Data Format (MBx, MEx)

Modbus registers contain 16 bit integer values. By using the following channel options, however, pairs of consecutive registers can be interpreted as containing a 32 bit integer or floating point value.

The following options specify how the *DT80* should interpret the contents of a Modbus register, or pair of registers:

- **MBI** - 16 bit signed integer (default)
- **MBU** - 16 bit unsigned integer
- **MBL** - 32 bit signed integer transferred using two consecutive 16 bit registers
- **MBF** - 32 bit IEEE-754 floating point value transferred using two consecutive 16 bit registers
- **MBLE** - 32 bit signed integer transferred using "Enron Modbus" protocol variant
- **MBFE** - 32 bit floating point value transferred using "Enron Modbus" protocol variant

If MBL or MBF are selected, the following two options can be used to specify the order in which the two halves of the 32 bit value are stored:

- **MES** - "straight endian" (default): the first register of the pair contains the upper 16 bits
- **MER** - "reverse endian": the first register of the pair contains the lower 16 bits.

Communications (TO, RT)

Two options control how communications errors or timeouts are handled.

The **TO***n* option specifies the timeout (*n*) in seconds for Modbus master requests (minimum=1, default=3)

The **RT***n* option specifies the number of retries to perform following a Modbus master error or timeout (default=0)

Unit ID (MUID)

The **MUID***n* option sets the Modbus "unit ID" field to *n* (0-255), and is only applicable for network connections (**4MODBUS**). It is typically used where the connected Modbus device is acting as a gateway to a serial Modbus network. In this case the unit ID represents the address of the device on the serial network that you wish to access.

Scaling

The standard *DT80* scaling facilities such as spans, polynomials and the channel factor can be used to scale the slave device's measurement units into the desired units for logging.

For example, if a device register contains a temperature in tenths of a degree Celsius you could specify a scaling factor of 0.1 using the channel factor, e.g.

```
1MODBUS(AD1,R3:22,0.1,"Temp~degC")
```

If the device instead measured in tenths of a degree Fahrenheit, a span could be used to apply a scaling factor and an offset:

```
S1=0,100,320,2120"degC"
1MODBUS(AD1,R3:22,S1)
```

In this example the span (see *Spans (Sn)* (P60)) is specifying that we want to indicate a value of 0 (degrees C) when we read a value of 320 (tenths of a degree F) from the device, and a value of 100 when we read a value of 2120.

The **SR***n* channel option can be used to apply a span in reverse. So if the above device also contained a setpoint register (also in tenths of a degree F), you could use the following to set the setpoint to 22.5 °C:

```
1MODBUS(AD1,R4:20,SR1)=22.5
```

Block Transfers

It is also possible to read a block of consecutive Modbus registers into a block of CVs. In this case the return value of the channel is the number of values transferred (which you would generally ignore by using the **W** option to make the channel a working channel). The actual data values are written to the specified CVs.

To do a block read, specify a starting register number and a CV range. The extent of the CV range specifies the number of registers to read. For example

```
1MODBUS(AD1,R3:21,=1..5CV)
```

will read input registers #21-25 into 1CV-5CV.

To write a block of CVs to a block of registers, a CV range can be specified where the expression would normally be, e.g.

```
1MODBUS(AD1,R4:1)=51..60CV
```

will set holding registers #1-10 to the values of 51CV-60CV.

In the following slightly convoluted example, the current values of 1CV-50CV can be copied to 101CV-150CV in one operation by telling the *DT80* to "poll itself"

```
4MODBUS(AD"127.0.0.1",R3:1,=101..150CV)
```

In this case the *DT80* will send a Modbus request to read input registers #1-50 to the Modbus slave at address 127.0.0.1. This address is a special "loopback" IP address, which will actually be received by the *DT80* itself. The *DT80* Modbus server will then process the request in the normal way. As indicated in the table in *Accessing DT80 Channels via Modbus* (P153), input registers #1-1000 are mapped onto 1CV-1000CV, so the *DT80* will reply to the request with the values of 1CV-50CV. The **MODBUS** channel will then process the reply and store the values into 101CV-150CV.

Note that in this example the CV values will be transferred using standard 16-bit Modbus registers, so an appropriate scaling factor should be applied using the **SETMODBUS** command if the CVs contain non-integer values.

Examples

Some further examples are given below.

- `1MODBUS(AD19,R3:100)` – read input register #100 from device with address 19 connected to serial sensor port
- `4MODBUS(AD"10.0.0.123",R3:100)` – as above, but read from a device with IP address 10.0.0.123
- `1MODBUS(AD1,R3:100,=10..19CV)` – read input registers #100-119 and save to 10..19CV
- `1MODBUS(AD1,R3:70,MBF)` – read input registers #70 and #71 and interpret as the high and low words respectively of a 32 bit IEEE-754 floating point value.
- `1MODBUS(AD1,R3:70,MBF,MER)` – as above, except that register #70 contains the low word and #71contains the high word (i.e. "little endian" format).
- `1MODBUS(AD1,R4:100)=235` – write 235 to holding (output) register #100

- **1MODBUS(AD1,R3:1,0.1)** – read input register #1 and multiply by 0.1 (often used when the register contains a fixed point value, e.g. it measures in tenths of a degree)
- **1MODBUS(AD1,R3:21,S2)** – read input register #21 and apply scale and offset as specified in span S2.
- **1MODBUS(AD1,R4:100,SR2)=1..3CV** – write 1..3CV values to holding registers #100-102, after applying span S2 in reverse to each value
- **1MODBUS(AD1,R1:100:8)** – read discrete inputs #100-107 and pack into a single 8-bit value with input #100 as the least significant bit.
- **1MODBUS(AD1,R0:100:16)=0xFFFF** – set coils #100-115 to 1
- **1MODBUS(AD1,R0:100)=4CV** – set coil #100 to 1 if 4CV is non-zero, 0 if 4CV is zero
- **1MODBUS(AD1,R1:100:16,=1..2CV)** – read discrete inputs #100-115 into 1CV, #116-131 into 2CV
- **1MODBUS(AD1,R3:100,MBF,=1..2CV)** – read input regs #100-101 as a floating point value and save to 1CV, read input regs #102-103 as a second floating point value and save to 2CV.

Troubleshooting

Setting **P56=4** will enable the output of diagnostic messages which allow you to see received and transmitted Modbus messages as they occur. This is described further in the Modbus slave section, *Troubleshooting* *(P156)*.

The TCP/IP loopback facility, where you specify the address 127.0.0.1 in order to cause the *DT80* to send Modbus messages to itself, can be a handy way to test your *DT80* program without requiring the connection of a real Modbus sensor. For example, you can simulate a sensor's input registers by setting a range of CVs, then reading them using the **MODBUS** channel – as described in *Block Transfers* *(P294)* above.

If the *DT80* is unable to communicate with a Modbus sensor, an error message will be reported, such as

```
1MODBUS(AD5,R3:1)
dataTaker 85 E124 - Modbus transaction failed
1MODBUS NotYetSet
```

Check the following:

- Ensure the address specified in the **AD** channel option matches the Modbus device's configured serial or IP address
- Ensure that all Modbus devices on the network have unique addresses.
- If the *DT80* has a manually configured IP address and the sensor is not on the same local network segment then ensure that the *DT80*'s Ethernet gateway is set correctly, using **PROFILE ETHERNET GATEWAY=***ip-addr*
- Ensure that the device actually supports the register number that you are trying to read. Make sure that you understand the convention that is used in the device's documentation for specifying register numbers.
- For serial Modbus, ensure that the serial port is set up correctly, using the appropriate profile settings. This includes port mode (RS485/422/232; serial sensor port only), port function (must be set to **MODBUS_MASTER**), baud rate and possibly other settings.
- For serial Modbus over RS422, ensure that the port is wired correctly with the *DT80* as the master.
- Ensure that there are no other Modbus master devices on the same serial network as the *DT80*. (For a TCP/IP network multiple Modbus master devices can be present.)
- If transactions are failing intermittently, electrical noise may be disrupting the network. If this cannot be rectified then it may help to use the **RT***n* channel option to tell the *DT80* to retry failed transactions a few times.

If the **MODBUS** channel is reliably returning values, but the values seem to be wrong, then check the following:

- Make sure you have specified the correct register number. Be careful of "off by one" problems, as some device documentation specifies 0-based protocol addresses, rather than the 1-based register numbers used by the **R** channel option.
- Has any required scaling factor or span been applied correctly? Double check the device documentation.
- For 32-bit integer or floating point quantities be sure to specify the correct data format option, e.g. **MBF** if the device returns an IEEE-754 floating point value, or **MBL** for a long integer.
- For 32-bit quantities, it is also quite possible that your device may require the **MBR** option as both "straight" and "reversed" word ordering are widely used.

Technical Details & Troubleshooting

DT80 Analog Sub-System

This section provides some technical details on the internal operation on the *DT80*'s analog measurement sub-system. This will allow the interested user to better understand its characteristics.

A simplified block diagram of the DT80/81's analog sub-system is shown below. In this diagram the circle-X symbols indicate relay contacts which can connect or disconnect the indicated points.

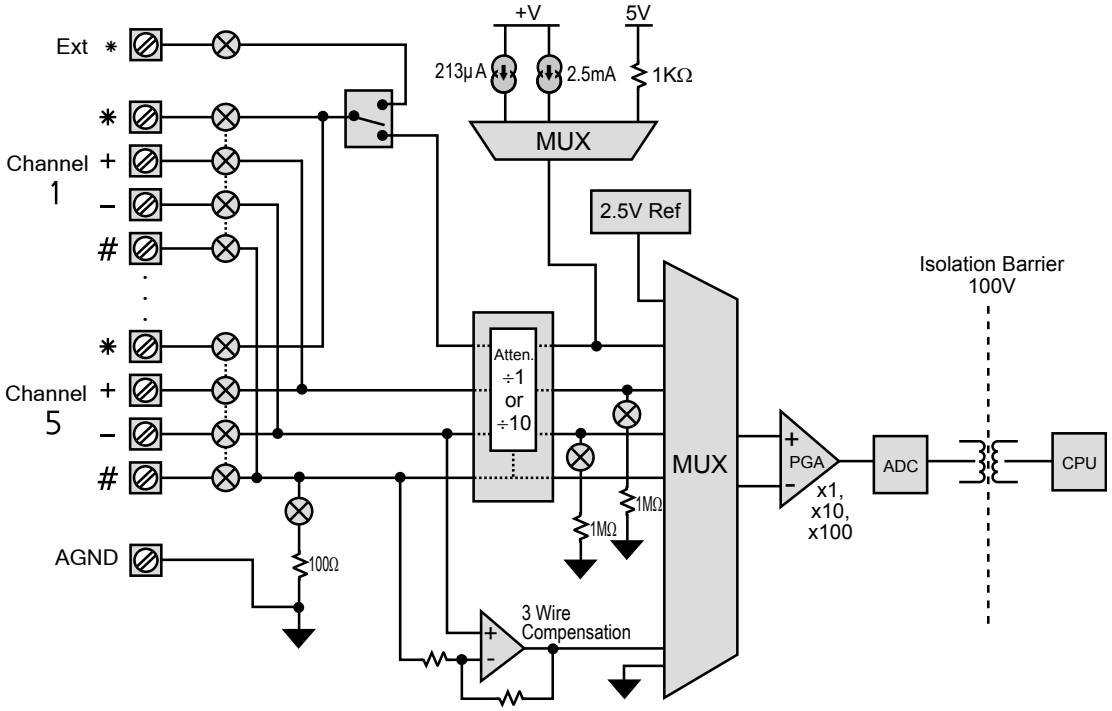


Figure 131: DT80/81 Series 1 Analog Sub-System

The DT80 Series 2 and DT85's analog sub-system is slightly different:

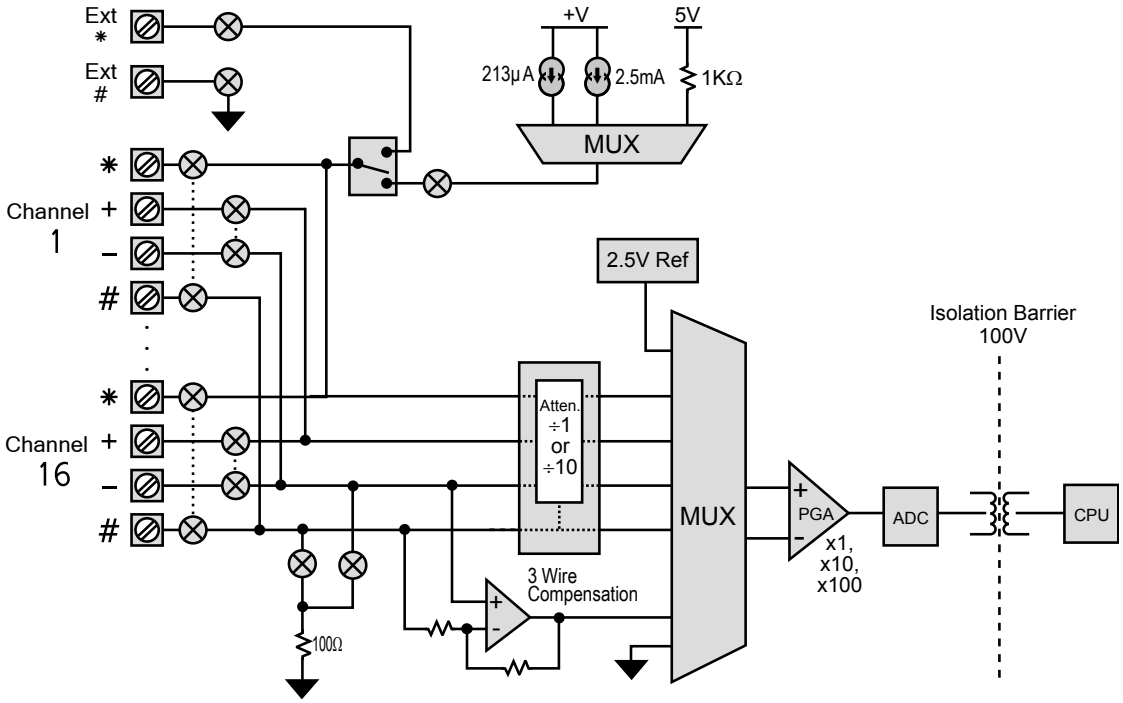


Figure 132: DT80 Series 2 and DT85 Analog Sub-System

The following sections discuss the various points to note about these diagrams.

Ground Terminals

The *DT80*'s analog section is electrically isolated from the rest of the unit. There are therefore two separate ground references – **digital ground** and **analog ground**.

The *DT80*'s front panel label further reinforces the separation of the analog and digital sections:

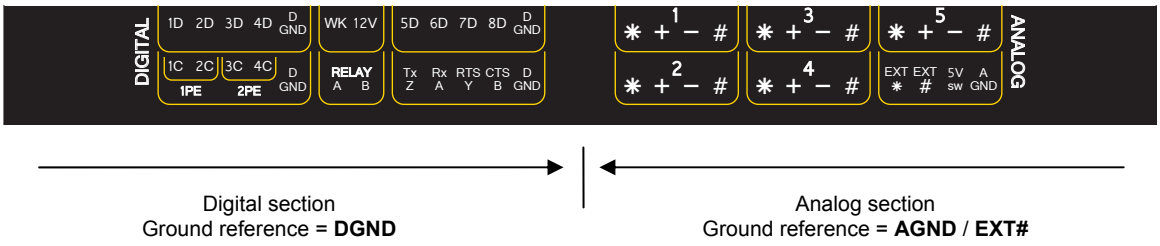

DIGITAL
1D 2D 3D 4D D GND
1C 2C 3C 4C D GND
1PE 2PE
WK 12V
RELAY A B
5D 6D 7D 8D D GND
Tx Rx RTS CTS D GND
Z A Y B
1 * + – #
2 * + – #
3 * + – #
4 * + – #
5 * + – #
EXT * EXT # 5V sw A GND
ANALOG
Digital section
Ground reference = DGND
Analog section
Ground reference = AGND / EXT#

Figure 133: The DT80 has two ground systems

Isolating the analog and digital sections means that sensor-to-equipment ground loops (see *Ground Loops* (P300)) are unlikely to arise. To preserve the *DT80*'s isolation these grounds should not normally be connected together.

An isolated analog ground also means that the *DT80* can reject a large common mode voltage on the input being measured because its analog ground can "float" up to match the common mode voltage. This means that the common mode voltage seen by the *DT80*'s amplifier will be small.

Digital Ground

The *DT80*'s digital ground is connected to the **DGND** terminals, as well as to the chassis earth point and the various "common" or "ground" terminals on the communications and power interfaces. Digital ground is the ground reference for:

- DC power input
- all communications links (including serial sensor port), if required
- digital and counter inputs and outputs
- DC power outputs **12V** and **PWR OUT** (DT80 Series 2 and DT85 only)
- cable shields

Analog Ground

The DT80's analog ground is shown by a black triangle symbol in the block diagram.

Most analog measurements will not require any ground reference connection, as the measurement is taken relative to the channel's **–** or **#** terminal. The only case were a ground connection is required is when making current measurements using the *DT80*'s internal shunt resistor. In this configuration the current to be measured flows in the # terminal, through the shunt resistor and returns via the analog ground terminal to the external current source. Refer to the wiring diagrams, e.g. *C3 – Independent Current Input using the internal shunt* (P238) for more details.

For the DT80/81, analog ground is permanently connected to the **AGND** terminals.

For the DT80 Series 2 and DT85, analog ground is connected to the **EXT#** terminals – but only when needed. That is, it is only connected during a measurement that uses the internal shunt resistor (e.g. **1#I**), or that uses externally generated excitation (**E** channel option). Switching the analog ground connection in this way means that a channel which does not require an analog ground connection (e.g. a thermocouple) can be completely isolated from a channel which does (e.g. a current loop which uses the internal shunt). With the DT80/81, the thermocouple channel would not be completely isolated from the current loop channel because the thermocouple channel's # terminal would be connected (via the shunt resistor) to the **AGND** terminal and therefore to the ground of the current loop.

For Series 3 models, a permanent **AGND** terminal is provided as the return for the switched isolated 5V power output, **5V SW**.

Input Switching

As shown in the block diagrams, each input terminal is switched via relay contacts. While an analog channel is being measured, its terminals are switched through to the analog input multiplexer. All other channels have all four of their input terminals disconnected, so they are completely isolated from the channel being measured.

For the DT80/81, the dotted lines between each channel's four relay contacts indicate that the four relay contacts are always switched together, so all four are either all open or all closed.

For the DT80 Series 2 and DT85, it can be seen that the contacts are split into two independently controlled pairs – one for the + and – terminals and one for the * and # terminals. This means that if two independent differential inputs are connected to the one channel then the two measurements will be fully isolated. That is, when you measure between + and – (e.g. **1TK**) the * and # terminals will be disconnected, and conversely when you measure between * and # (e.g. **1*TK**) the + and – terminals will be disconnected. This isolation improves measurement accuracy in situations where the two inputs have

different common mode voltages.

Input Termination

The *DT80*'s instrumentation amplifier has a very high input impedance. With such devices, it is necessary to provide a path to allow the device's inherent "bias current" to flow to ground. If this is not done then the inputs will "float", possibly causing significant inaccuracies.

For the DT80/81, when a measurement is made relative to the # terminal (e.g. **1+V**), the 100Ω shunt resistor between the # terminal and AGND provides a ground path, thereby preventing any problems due to floating inputs. However, when a measurement is made between the + and – terminals (e.g. **1V**), the shunt resistor will not be connected to the amplifier input. For such measurements, it is necessary to **terminate** the inputs. This input termination is provided by a pair of 1MΩ resistors, as shown in the block diagram. These are automatically switched in whenever a voltage measurement is made using the + and – terminals (e.g. **1V**, **1TK** etc.), or they can be switched in manually using the **T** (terminate) channel option.

The use of these termination resistors will decrease the input impedance of the *DT80* to around 1MΩ. That is, it will increase the load on the voltage source being measured. This will generally only be a problem if the source has a very high output impedance.

Also note that the ground reference provided by the 1MΩ termination resistors is not as effective as that provided by the 100Ω shunt resistor. For this reason, when performing an independent voltage measurement it is usually preferable to make the measurement relative to the # terminal rather than the – terminal; that is **1*V** rather than **1V**.

For the DT80 Series 2 and DT85, these termination resistors are not required, and the **T** option will have no effect. This is because the 100Ω shunt resistor can be connected to either the – or the # terminal, as shown in the diagram. This resistor will therefore provide a ground path for all input configurations.

Attenuator

To extend the input voltage range, the *DT80* provides a switchable input attenuator. This is a resistive voltage divider which attenuates the input by approximately 10:1. The attenuator is enabled by default for the **HV** (high voltage) channel type, or it can be enabled manually using the **A** channel option.

As indicated in the diagrams, there is no attenuator on the # input. This means that input attenuation is not available for # terminal measurements (which would typically be current measurements using the internal shunt resistor, e.g. **1#I** or **1#L**).

Furthermore, the excitation switching arrangement on the DT80/81 means that attenuation cannot be used if the logger is supplying excitation from one of its internal sources. This restriction does not apply to the DT80 Series 2 and DT85.

Note that when the attenuator is used the *DT80*'s input impedance will decrease to approximately 100kΩ.

Excitation

Some measurements require that the sensor be **excited** in order for a measurable output voltage to be produced. For example, to measure a resistance an excitation current is passed through the resistance and the resulting voltage drop is measured.

As shown in the block diagrams, there are some differences between the DT80/81 and the DT80 Series 2/DT85 in the way excitation is switched. These do not, however, affect the way that excitation is used from the user's point of view, other than the caveat mentioned above regarding attenuation.

Internal Sources

If excitation is required, the *DT80* provides three internal excitation sources:

- precision current source, approx. 213µA. This is the default for the **R** (resistance), **NI** (RTD) and **YS***nn* (thermistor) channel types, or can be selected manually using the **I** channel option.
- precision current source, approx. 2.5mA. This is the default for the **BGI** (bridge), **PT***nnn* (RTD) and **CU** (RTD) channel types, or can be selected manually using the **II** channel option. This setting provides for more accurate measurements of low resistances, at the expense of a reduced measurement range.
- voltage source, approx 4.5V. This is the default for the **BGV** (bridge) and IC temperature sensor (e.g. **AD590**, **LM135** etc) channel types, or can be selected manually using the **V** channel option. This output has a 1kΩ output impedance, so the output voltage will drop if any significant current is drawn.

If one of these sources is selected, it will be switched through to the * terminal of the channel being measured. The excitation current returns via the channel's # terminal, then through the shunt resistor to analog ground. Note that the excitation is only connected to the channel's terminals for the duration of the measurement.

For Series 3 models, the 213µA current source may be connected to the + or – terminals, as well as the * terminal. This allows 2-wire resistance measurements to be performed between + and – or between # and any of the other three terminals.

External Sources

Alternatively, an external excitation source may be provided. There are two options here:

- The source can be connected directly to the sensor. The *DT80* then measures the required voltage. As far as the *DT80* is concerned, it is just measuring a voltage; it is not concerned with providing excitation. The **N** (no excitation) channel option may therefore be used to indicate this configuration. For example, refer to the bridge wiring diagram: *B1 – 6-Wire BGV Inputs* *(P243)*.

- A single source can be used to excite multiple channels. In this configuration the external supply is connected to the **EXT*** terminal, and the return to **AGND** (DT80/81) or **EXT#** (DT80 Series 2/DT85). The *DT80* will then switch this source through to the * terminal of the channel being measured. The excitation current then returns via the channel's # terminal, through the internal shunt to analog ground, then back to the excitation supply via the **AGND/EXT#** terminal. If desired, the 12V power output on the DT85 and DT80 Series 2 can be connected to **EXT*** as an excitation source, see also *Controlling 12V Power Output* (P225).

Note that in the first case the sensor is continuously excited, while in the second it is only excited during an actual measurement (similar to internal excitation). Exciting a sensor only when needed is beneficial from a power consumption standpoint, and it will help minimise self-heating issue in sensors such as thermistors. In some cases, however, a sensor may require a certain warm up time. In this case the **MD** (measurement delay) channel option may be used to extend the measurement time)

Note also that external excitation cannot be used for channels such as **R** (resistance) or **BGI** (current excited bridge) where the *DT80* needs to accurately know the excitation current in order to calculate the quantity being measured. For these channel types one of the precision internal current sources must be used.

3-Wire Compensation

The 3-Wire Compensation circuit is used for 2 and 3 wire resistance measurements. It will therefore be used by default for any resistance measurement, unless the **4W** option is used to specify a 4-wire measurement.

In a 3-wire measurement, excitation current flows out of the * terminal, through the excite wire, through the resistance being measured, then back via the return wire to the # terminal. The measurement is then made between the + terminal (which is shorted to *) and, using a third "sense" wire, the negative end of the resistance being measured. This measurement will include the voltage drop across the excite wire, as well as that across the unknown resistance. See *R2 – 3-Wire Resistance Inputs* (P240).

The 3-wire compensation circuit works by measuring the voltage drop across the return wire (i.e. between the sense point and the # terminal), multiplying it by 2 (to account for the voltage drop in the excite wire, which is assumed to be equal to that in the return wire), then using this voltage to offset the negative input of the instrumentation amplifier. This will effectively subtract the cable's voltage drop, thereby compensating for the effect of the cable resistance.

For a 2-wire measurement there is no sense wire. The return wire connects to the – terminal, so the measurement now includes both the excite and the return resistance. This can then be manually compensated for by inserting a resistor equal to the total cable resistance between the – and # terminals. The excitation current will flow through this resistor, generating a voltage drop which will then offset the amplifier input in a similar way to a 3-wire measurement.

Calibration and Characterisation

There are two main sources of error in an electronic instrument such as the *DT80*:

- variations in component values or characteristics due to manufacturing tolerances
- variations in component values or characteristics due to ambient temperature

During production, the actual values for certain circuit parameters are measured (using test equipment traceable to ISO standards) and then stored permanently into the DT80 memory. This process is known as **characterisation**. Once the *DT80* has been characterised, the firmware can correct for these variations. These stored values can be listed using the **CHARAC** command (see *CHARAC Command* (P214)).

Some circuit characteristics are, however, inherently temperature dependent. If the *DT80* is to return accurate readings over the full temperature range then these characteristics must be corrected for as well. This cannot be done in the factory; it must be done during operation, as the temperature goes up and down. This process is known as **calibration** (not to be confused with characterisation).

On power-up and at regular intervals during operation, the *DT80* measures the amplifier's internal "offset voltage". If it is found to have drifted by a specified amount (3µV by default, can be adjusted using parameter P0) then a **calibration cycle** is performed. This process takes approximately one second and involves the *DT80* measuring several different internal parameters, such as offset voltages (amplifier output with no input applied) for various input configurations, and the actual values of the *DT80*'s internal current sources. These readings are then used for all subsequent analog measurements, until the next calibration cycle occurs.

The **TEST** command will force a calibration cycle, and return the values of most of the measured calibration parameters.

To summarise: the DT80 has certain temperature-stable characteristics, whose absolute values are measured and recorded during manufacture. This process corrects for any differences between individual units. Using these characterised values, further measurements are taken during operation to correct for differences between the current temperature and the temperature at which the factory characterisation was performed.

Analog Warm Up Time

By default (**P21=0**), the *DT80*'s analog section will be powered up 50ms prior to execution of a schedule containing analog channels, and then powered down once the schedule is complete. This minimises overall power consumption.

The 50ms delay allows some time for the analog power supply to stabilise. However, the analog circuits also exhibit a "warm up" characteristic. This means that readings may vary slightly during the first few minutes after the analog section is powered up, until the components' temperatures stabilise. This is not normally a concern because:

- the automatic calibration process ensures that temperature related drift is compensated for

- in most systems all analog measurements in a schedule are completed within a second or so of each other so the differences in readings due to the analog warm up characteristic are negligible.

If power consumption is not a concern then the analog section can be kept powered all the time by setting **P21=1**. This will generally reduce the number of calibration cycles which occur due to analog warm up. Calibration cycles will, of course, still occur if the ambient temperature changes.

Grounds, Ground Loops and Isolation

Experience has shown that ground loops (sometimes called "earth loops") are the most common cause of measurement difficulties. Excessive electrical noise, unexpected offset voltages and erratic behaviour can all be caused by one or more ground loops in a measurement system.

Grounds are Not Always Ground

Electrical grounds in a measuring system can be an elusive cause of errors.

In the real world, points in a system that one could reasonably consider at ground potential are often at different and fluctuating AC or DC potentials. This is mainly due to earthed neutral returns in power systems, cathodic corrosion protection systems, thermocouple effects in metal structures, lightning strikes and solar storms. Whatever the cause, the result can be loss of measurement integrity.

Ground Loops

If grounds of different potential are connected by cabling used in the measuring system, ground currents flows — this is the infamous **ground loop**. The magnitude of the currents can be from milliAmperes to tens of Amperes, and in the case of a lightning strike, can be thousands of Amperes. Frequently, voltage drops along cables (caused by these current flows) are superimposed on the desired signal voltage.

A ground loop can arise when a measurement system has more than one path to ground. As *Figure 134* shows, this can be caused by

- connecting a sensor to a ground point that has a different potential to the ground of another sensor — a **sensor-to-sensor** ground loop is likely to flow through the return wires of the two sensors
- connecting the *DT80* to a ground point that has a different potential to the ground of one or more of the sensors or instruments connected to the *DT80* inputs — a **sensor-to-equipment** ground loop
- connecting the *DT80* to a ground point that has a different potential to the ground of the host computer — an **equipment-to-computer** ground loop.

In these situations, conduction paths can occur from one ground point to another through the sensor and/or equipment and/or computer, making measurement errors inevitable (particularly if sensor wires are part of the conduction path).

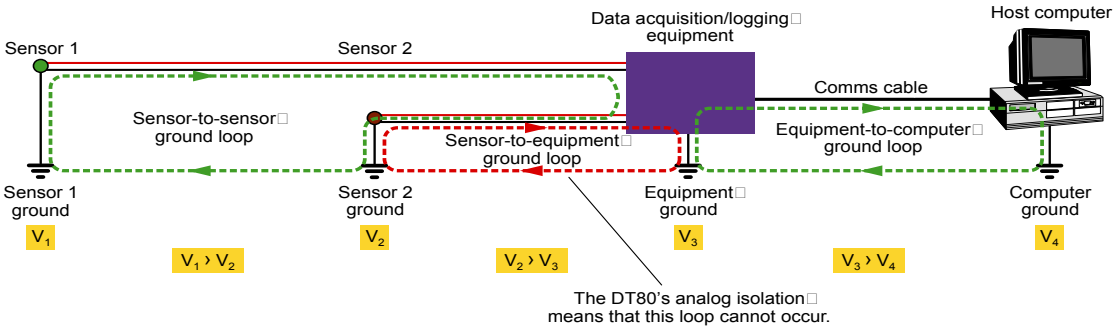


Figure 134: Some of the possible ground-loops in a measurement system

Avoiding Ground Loops

For each type of ground loop, the basic strategy is to break the ground loop.

Isolation

The design of the *DT80* helps eliminate ground loops between the sensors and the *DT80*/computer, because the *DT80* provides over 100V of **isolation** between the **analog section** (which connects to analog sensors) and the **digital section** (which connects to digital devices and computers).

The ground point for the analog section is the internal **analog ground**, which is electrically isolated from the "system" ground (**DGND** terminal).

Furthermore, each analog channel is electrically isolated (to 100V) from other channels.

See *Ground Terminals* (P297) for more details.

Connecting Sensors

The following points should be considered:

- There should normally not be any external connection made between **AGND/EXT#** and **DGND**.

- The sensor's "return" wire should be grounded at one end only (the *DT80* end) of the sensor cable. Normally the return wire would be connected to the **-**, **#** or **AGND/EXT#** terminal on the *DT80*.
- There should be no connection to ground at the sensor itself, unless that connection is isolated from the sensor return wire. For example, if the sensor has its own power supply then the power supply should be isolated from ground (e.g. by using a transformer-isolated mains supply)
- Use an independent input configuration in preference to a shared configuration.

Noise Pickup

There are two main ways in which noise can be introduced into signal wiring: by capacitive coupling and by magnetic induction. There are different counter-measures for each.

Shield signal wiring to minimize capacitive noise pick-up. Signal wiring that is close to line voltage cable should always be shielded.

Shields should be connected to system ground (**DGND**) at the *DT80* end only.

Magnetic induction of noise from current-carrying cables or from electrical machines (especially motors and transformers) is a greater problem. Shielded cable is not an effective counter-measure. The only practical measures are to

- avoid magnetic fields
- use close-twisted conductors for the signal wiring.

Shielding in steel pipe can be effective, but is generally not economic or convenient.

Noise Rejection

The *DT80* is designed to reject mains noise. For best noise rejection, set the *DT80*'s parameter 11 to your local mains frequency, 50Hz or 60Hz — see *P11* *(P201)*.

To force the *DT80* to load this parameter setting every time it restarts use the following command

```
PROFILE PARAMETERS P11=60  'for 60Hz line frequency
```

Self-Heating of Sensors

Sensors that need excitation power to be read are heated by power dissipation. This issue can be particularly acute with temperature sensors and some sensitive bridges. If self-heating is a problem, consider:

- selecting 200µA excitation (**I** channel option) in preference to 2.5mA excitation (the trade-off is a reduction in the range of resistances that can be measured).
- reducing measurement time, e.g. setting **P11=200** will reduce the time spent exciting the sensor from the default 20ms to 5ms (the trade-off is a reduction in mains noise rejection).

Getting Optimal Speed from Your *DT80*

In applications where it is important to sample as rapidly as possible, the following guidelines may assist:

- Switch off data return and logging for channels you are not interested in.
- Set **P21=1** so that the analog power supply is always on. This prevents the 50ms warm-up delay which can occur if there is any gap between schedule execution.
- Similarly, if any CEM20 units are in use then set **P28=1** so that 12V output for powering the CEM is always on,
- Set P11 to a higher value, which will reduce the time over which an analog acquisition is integrated. For example, if P11 is changed from 50 to 500 then the sample time will be reduced from 20ms to 2ms. Be aware that this will cause a degradation in the *DT80*'s ability to reject noise.
- Reduce the channel's settling time, using the **MD***n* channel option. The default is 10ms. It is not recommended to reduce this below 5ms because the *DT80*'s relays need about this long to switch before a measurement can commence.
- Disable automatic calibrations using **/k**. Be aware that readings will now be subject to drift with temperature.
- Set **P62=1**, which will leave the *DT80*'s relays set when the schedule completes (normally they are set back to a quiescent state at the end of a schedule). If you are measuring a single voltage input then you will now be able to do repeated samples without changing the relay settings at all, which would then allow you to reduce the settling time to zero (i.e. **MD0**)

Part O – The CEM20

Figure 135: A CEM20 module (left), shown connected to a DT80

What is the CEM20?

The *dataTaker CEM20* (**Channel Expansion Module**) is an analog multiplexer specially designed to work with *DT80* series data loggers (Series 2 only). Each CEM20 provides 20 additional analog channels. Up to five CEM20s can be connected to a DT80 and fifteen to a DT85, giving a total of 100 and 300 analog input channels respectively.

The CEM20 contains relay multiplexers which connect the selected channel through to one of the *DT80*'s analog inputs. In order to measure a sensor connected to a CEM20 input:

1. The *DT80* will first send a command to the appropriate CEM20, which will cause it to connect the required input through to its analog output terminals.
2. The CEM20's analog output terminals are wired to one of the *DT80*'s analog input channels, so the *DT80* will then simply perform a normal analog measurement on the appropriate channel.

Measuring a sensor connected to a CEM20 channel is therefore just like measuring one that is directly connected to the *DT80*. The main difference is that the measurement will take longer (typically about twice as long) due to the extra step involved.

Connecting CEM20s

As shown in the photograph above, there are two main connections to each CEM20, namely:

- a 4-wire power/control connection (the upper cable in the photograph). This cable connects to the *DT80*'s switched 12V power output in order to supply power to the CEM. The cable also contains two control signals, which are driven by two of the *DT80*'s digital outputs: **5D** and **6D**.
- an 4-wire analog connection. This connects the analog output of the CEM20 to one of the *DT80*'s analog inputs. Each CEM20 connects to a separate analog input on the logger. (Thus for every CEM20 that you connect, you gain 20 analog inputs but lose one analog input on the logger.)

The photograph shows a single CEM20. To connect a second CEM20:

- Each CEM20 includes a power/control output terminal block, located directly above the power/control input. This can be used to "daisy chain" the power and control signals to the next CEM20.
- The analog output of the second CEM20 then connects to the second analog input on the *DT80*, in the same way as the first CEM20, which connects to the first analog input.

The following diagram shows the required wiring in detail. In this case a DT80 is shown connected to two CEM20s. Several K-type thermocouples are also shown, connected to analog inputs on the CEM20s and on the logger itself. Using this "dual isolated" method of connecting thermocouples (as per *V2 – Independent Voltage Inputs* (P236)), up to 86 fully isolated thermocouples could be connected – 40 on each CEM20 (two per analog input) plus another 6 on the remaining 3 analog inputs (inputs 3, 4 and 5) on the DT80.

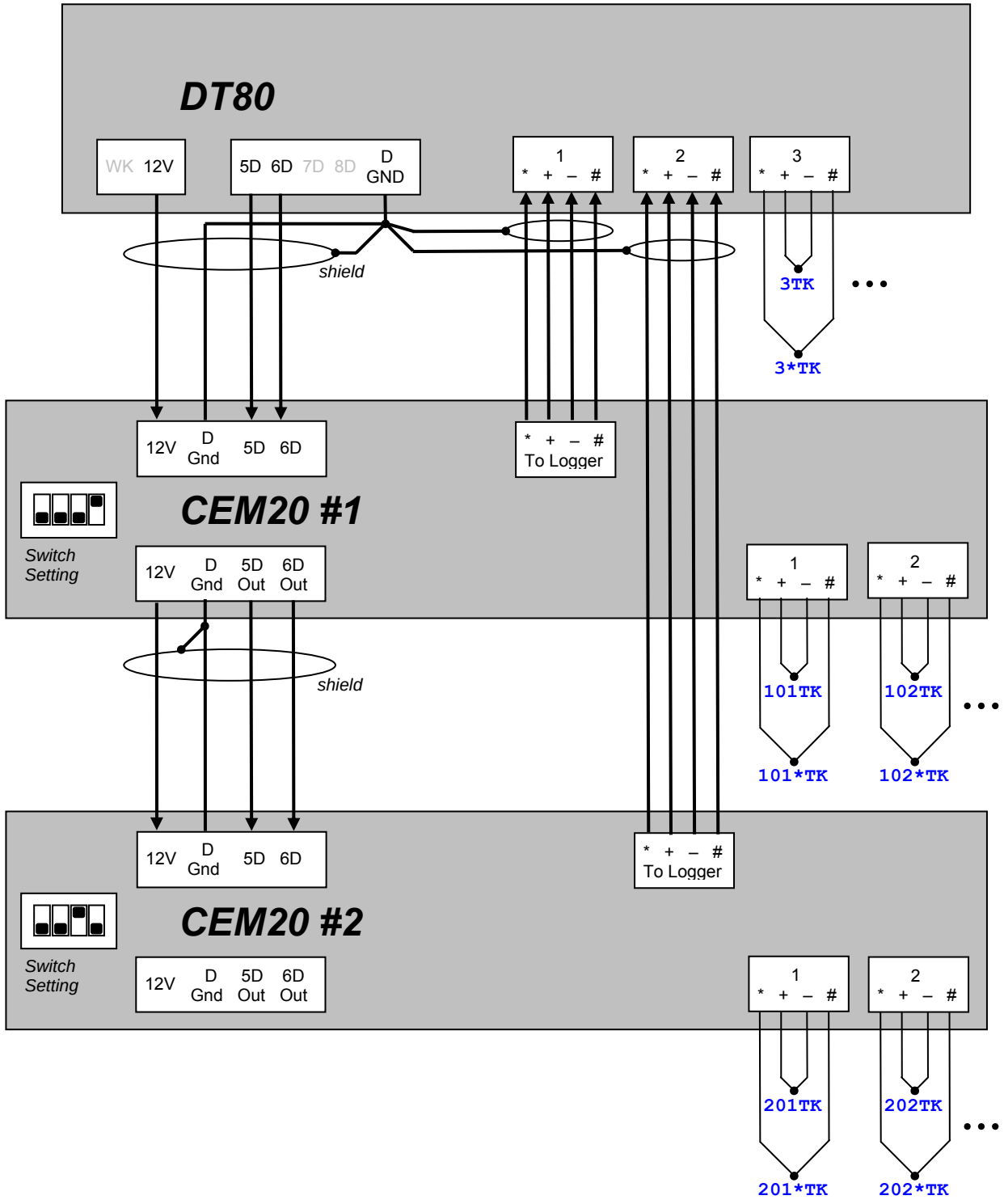


Figure 136: A DT80 connected to two CEM20s and set up to measure an array of thermocouples

Note the following points about the wiring diagram:

- Each CEM20 is supplied with two pre-wired connecting cables: a power/control cable and an analog cable. These are suitable for connecting the first CEM20 the logger. To connect the second and subsequent CEM20s, it will be necessary to replace the "5+2" terminal connector on one end of the power/control cable with a single 4-way terminal block to suit the output on the CEM20. It may also be necessary to extend the length of the analog cable.
- Shielded cable is recommended. The cable shield should be connected to DGND at one end only, as shown in the diagram. It is not necessary for everything to use the one DGND terminal – shields may be connected to any of the DGND terminals on the logger, or to the earth point on the metal end plate.

- The maximum total cable length, from the *DT80* to the last CEM20 in the chain, is 100 metres.
- In the diagram, the two CEM20s have been assigned addresses 1 and 2. However any addresses could have been chosen. The only rule is that a CEM20 with address *n* must have its analog output connected to analog input *n* on the *DT80*.

CEM20 Addresses

CEM20s are identified by their **address**, which is set using the 4-way DIP switch on the end plate of the CEM20.

Each CEM20 must be set to a unique address before installation.

A CEM20's address determines where its analog output should be connected and how its channels should be referenced. For example, a single CEM20 could be attached to a *DT80* and set to address 5. This CEM20 would then connect to analog input 5 on the *DT80,* and its channels would be referred to as **501**, **502** etc.

The following table shows the required switch settings for each CEM20

CEM20 Address	Switch 1	Switch 2	Switch 3	Switch 4
1	-	-	-	ON
2	-	-	ON	-
3	-	-	ON	ON
4	-	ON	-	-
5	-	ON	-	ON
6	-	ON	ON	-
7	-	ON	ON	ON
8	ON	-	-	-
9	ON	-	-	ON
10	ON	-	ON	-
11	ON	-	ON	ON
12	ON	ON	-	-
13	ON	ON	-	ON
14	ON	ON	ON	-
15	ON	ON	ON	ON

Powering the CEM20

The recommended method of powering the CEM20 is to use the switched 12V power output on the *DT80*, as shown in *Figure 136*. This output is capable of powering up to 15 CEM20 units.

By default, the *DT80*'s 12V output will only be switched on during execution of a schedule containing CEM20 channels. Other modes of operation are possible, however, and are selected using parameter P28, as described in *Controlling 12V Power Output* *(P225)*. In particular:

- set **P28=0** (default) to switch CEM20 power on and off as required. This minimises power usage.
- set **P28=1** and **P21=1** to keep the CEM20s and the *DT80*'s analog measurement system powered up continuously. This will obviously use more power but will avoid the 50ms "warm up" delay that the *DT80* inserts when switching on either or both of these power supplies.
- set **P28=3** if the CEM20s are independently powered using an external power supply. The *DT80*'s 12V output may then be used to power other equipment if required and manually controlled using **PWR12V=**.

Note that if the CEM20s are externally powered then a regulated 12V ±5% supply is required.

Accessing CEM20 Channels

CEM20 channels are numbered in the same way as regular channels, but with the CEM number as the hundreds digit. Thus the first CEM20's channels are numbered from 101 to 120, the second from 201 to 220 and the fifteenth from 1501 to 1520. So to measure a thermocouple connected to the + and – terminals on first analog input channel on CEM20 #1 you would enter **101TK** – as shown on the wiring diagram.

Channel sequences (see *Channel Number Sequence* *(P30)* can cross CEM boundaries. For example,

```
RA1M 119..203V
```

is equivalent to

```
RA1M 119V 120V 201V 202V 203V
```

.

Likewise, an array of 86 isolated thermocouples connected as per *Figure 136* could be read using:

```
RA1M 3..220TK 3*..220*TK
```

CEM20 Temperature Reference

Each CEM20 includes a precision RTD temperature sensor. This is used to measure the reference junction temperature when thermocouple measurements are performed using the CEM20's analog inputs (see *Temperature – Thermocouples (P246)*. This process is automatic and is part of the normal thermocouple measurement process.

A CEM20's internal temperature sensor can be read at any time (for testing purposes) using the *n***REFT** channel, where *n* is the CEM number (1-15). So to read the current reference junction temperature for the first CEM20 you would enter **1REFT**. (To read the *DT80*'s internal temperature sensor use the **REFT** channel – no channel number.)

Troubleshooting

In the event that invalid readings are obtained when reading CEM20 channels, the following troubleshooting procedure may be helpful.

The key diagnostic aid is the red **Sample** LED on the CEM20, which will flash when it is commanded to take a measurement. For example, if you measure input 7 on CEM20 #12 (e.g. by typing **1207V**), you should see the red **Sample** LED on CEM20 #12 flash, along with the blue **Sample** LED on the *DT80*. No other CEM20s should flash their LED.

CEM20 Sample LED does not flash

If the appropriate CEM20's **Sample** LED does not flash when one of its inputs is measured then the most common explanations are:

- the CEM20 address switch is not set correctly. The CEM20 connected to analog input 1 on the *DT80* must be set to address 1 (switch setting: off, off, off, ON), the CEM20 connected to analog input 2 must be set to address 2 (switch setting: off, off, ON, off) and so on.
- the power/control cable to the CEM20 is not connected properly. Double check the wiring against the wiring diagram. Do not confuse the CEM20's power/control input (lower terminal block) and its power/control output (upper terminal block). Also, when connecting to a DT85, be sure that the 2-way terminal block on the cable is correctly plugged in to the 3-way terminal block on the DT85 (i.e. the wire should connect to the **12V** terminal).
- the CEM20 is not powered. If the CEM20 is powered from the *DT80*'s **12V** output then check that the P28 setting is correct; it should be set to 0, 1 or 2. If the CEM20 is powered externally then check that 12V ± 5% is present.
- there is a hardware or cabling problem with one of the "upstream" CEM20s. Try temporarily bypassing them by disconnecting the cable from CEM20 #1's power/control input and connecting it instead to the CEM20 in question. Then issue the same measurement command (it is not necessary to change the address of the CEM20). If this reading is satisfactory then it should be possible by a process of elimination to determine which CEM20 or power/control cable is faulty.
- you are using a Series 1 *DT80*. The CEM20 requires a Series 2 unit.

CEM20 Sample LED flashes, but reading is invalid

Possible explanations are:

- faulty sensor. Check by plugging it into one of the *DT80*'s analog inputs.
- the analog cable of the CEM20 is not connected properly. Double check against the wiring diagram; in particular check that it is plugged into the correct *DT80* channel (a CEM20 set to address *n* must connect to *DT80* analog input *n*)
- multiple CEM20s are being selected. Ensure that the **Sample** LED flashes on one and only one CEM20.
- electrical noise – ensure that the cable shield is connected to a **DGND** terminal (as shown in the wiring diagram) or to the *DT80* chassis earth point.
- faulty analog input on CEM20 or *DT80*. Disconnect the CEM20 and connect a sensor directly to the *DT80* analog input previously used by the CEM20. This should identify whether the CEM20 or *DT80* is at fault.

It may also be helpful to try reading the internal temperature sensor on the CEM20 (e.g. type **12REFT** to read the current temperature of CEM20 #12). This will eliminate any external sensor issues.

Part P – Reference

DT80 Series Specifications

Analog Inputs

Max Number of Inputs

Input Type	DT81	DT82	DT80	DT85	DT80 + 5 x CEM20	DT85 + 15 x CEM20
3-wire & 4-wire independent inputs	1	2	5	16	100	300
2-wire independent inputs	2	4	10	32	200	600
2-wire shared terminal inputs	3	6	15	48	300	900

Supported Measurement Types

- voltage
- current and 4-20mA current loop (internal or external shunt)
- resistance (2, 3, 4 wire; max 10kΩ)
- ratiometric resistance e.g. strain gauges (1/4, 1/2 or full bridges; current or voltage excited)
- thermocouples: types B, C, D, E, G, J, K, N, R, S, T (internal or external reference junction sensor)
- RTDs (Pt, Ni, Cu)
- thermistors (YS400xx series; generic thermistor scaling)
- IC temperature sensors (AD590 series, LM35 series, LM135 series)
- frequency
- vibrating wire strain gauges (*DT80G/85G GeoLogger only)*
- Carlson meters
- logic state

Input Ranges

Input Type	Range	Resolution
DC Voltage	±30 mV	0.00025 mV
	±300 mV	0.0025 mV
	±3000 mV	0.025 mV
	±30 V	0.00025 V
DC Current Internal Shunts(100Ω)	±0.3 mA	0.0000025 mA
	±3 mA	0.000025 mA
	±30 mA	0.00025 mA
External Shunts	depends on shunt	depends on shunt
Resistance	10 Ω	0.00015 Ω
	100 Ω	0.0015 Ω
	1000 Ω	0.015 Ω
	10,000 Ω	0.15 Ω
Frequency	0.1 to 10,000 Hz	0.0002%
4-20mA Current Loop	0 to 100%	0.01%
Temperature	depends on sensor	depends on sensor
Strain Gauges and Bridges	$\pm10^4$ ppm	1 ppm
	$\pm10^5$ ppm	10 ppm
	$\pm10^6$ ppm	100 ppm
Analog State	0 or 1	1

Accuracy

Maximum measurement error is given by:

*error = (reading * Basic Accuracy) + (FullScale Reading * 0.01%)*

where *Basic Accuracy* is as specified in the following table:

	5ºC to 40ºC	-45ºC to 70ºC
DC voltage measurement	±0.1%	±0.35%
DC current measurement	±0.15%	±0.45%
DC resistance measurement	±0.1%	±0.35%
Frequency measurement	±0.1%	±0.25%

Input Characteristics

Limit	min	typ	max	unit
Input terminal voltage **Warning** Voltages outside this range can cause permanent damage.	-35	-	35	V
Common mode voltage	-3.5	-	3.5	V
Common mode voltage, attenuators enabled	-35	-	35	V
Input impedance	100M	-	-	Ω
Input impedance, attenuators enabled	100k	-	-	Ω
Inter-channel isolation (relay)	100	-	-	V
Analog/digital isolation (opto)	100	-	-	V
Internal shunt resistance	-	100	-	Ω
Sample rate	-	-	25	Hz
Common mode rejection	90	-	-	dB
Line series mode rejection	35	-	-	dB
Effective resolution	-	-	18	bits

Excitation

- voltage source, 4.5V
- precision current sources: 213µA or 2.5mA
- switched external excitation input
- general purpose switchable 12V regulated power output for powering sensors & accessories. (max 150mA) (*not DT80/81 Series 1)*
- isolated switchable 5V regulated power output (max 15mA) *(series 3 only)*

Digital Inputs and Outputs

Max Number of I/O

Input Type	DT81	DT82E	DT82I	DT80	DT85	DT85/85L Series 3
Open drain digital input/outputs, pull-up	3	3	4	4	4	4
Logic input/outputs. tri-stateable, pull-down	1	1	-	4	4	4
Relay contact outputs	1	1	1	1	1	1
User LED outputs (**Attn**)	1	1	1	1	1	1
Low speed counter inputs (shared with digital I/O)	4	4	4	8	8	8
High speed counter inputs with programmable TTL or low threshold inputs	2	2	2	2	2	2
High speed counter inputs with TTL-level inputs	2	2	2	2	2	2
High speed counter inputs with TTL-level inputs (shared with digital I/O	-	-	-	-	-	3
Phase encoder (quadrature) inputs (shared with high speed counter inputs)	1	-	2	2	2	3

Input Characteristics

Terminal	Limit	min	typ	max	unit
1D-4D (**1D-3D** for DT81/82)	Input terminal voltage **Warning** Voltages outside this range can cause permanent damage.	-0.6	-	30	V
	Input high voltage	3.0	-	-	V
	Input low voltage	-	-	0.75	V
5D-8D (4**D** for	Input terminal voltage **Warning** Voltages outside this range can cause permanent damage.	-0.6	-	20	V

DT81/82)	Input high voltage	3.0	-	-	V
	Input low voltage	-	-	0.75	V
	Low speed counter input frequency		-	25	Hz
	Low speed counter input pulse width	20	-		ms

Output Characteristics

Terminal	Limit	min	typ	max	unit
1D-4D (**1D-3D** for DT81)	Output sink current (output low)	-	-	100	mA
	Output high voltage (no load)	-	4.1	-	V
	Pull up resistance	-	47k	-	Ω
5D-8D (4**D** for DT81)	Output high voltage	-	4.1	-	V
	Pull down resistance	-	200k	-	Ω
1RELAY	Contact rating @ 30Vdc	-	-	1.0	A

High Speed Counter Inputs

Input Characteristics

Terminal	Limit	min	typ	max	unit
1C-2C	Input terminal voltage **Warning** Voltages outside this range can cause permanent damage.	-10	-	10	V
	Input high voltage – counter mode, e.g. **1HSC**	2.1	-	-	V
	Input low voltage – counter mode	-	-	0.75	V
	Input high voltage – phase encoder mode, e.g. **1PE**	3.0	-	-	V
	Input low voltage – phase encoder mode	-	-	0.8	V
	Input high voltage – low threshold option, e.g. **1HSC(LT)**	7	-	-	mV
	Input low voltage – low threshold option	-	-	2	mV
	Input low pulse width – relay/switch input	40	-	-	µs
	Input high pulse width – relay/switch input	1400	-	-	µs
	Input frequency – relay/switch input	-	-	500	Hz
	Input low pulse width – 5V TTL input	40	-	-	µs
	Input high pulse width – 5V TTL input	20	-	-	µs
	Input frequency – 5V TTL input	-	-	10k	Hz
3C-4C **5C-7C**	Input terminal voltage **Warning** Voltages outside this range can cause permanent damage.	-30	-	30	V
	Input high voltage – counter mode, e.g. **3HSC**	3.0	-	-	V
	Input low voltage – counter mode	-	-	0.6	V
	Input high voltage – phase encoder mode, e.g. **2PE** (DT80), **1PE** (DT81)	3.0	-	-	V
	Input low voltage – phase encoder mode	-	-	0.8	V
	Input low pulse width – relay/switch input	10	-	-	µs
	Input high pulse width – relay/switch input	1400	-	-	µs
	Input frequency – relay/switch input	-	-	500	Hz
	Input low pulse width – 5V TTL input	10	-	-	µs
	Input high pulse width – 5V TTL input	5	-	-	µs
	Input frequency – 5V TTL input	-	-	10k	Hz

Serial Channels

Number of Ports

Item	DT81	DT82E	DT82I	DT80	DT85
SDI-12 network connections (shared with digital I/O)	1	1	-	4	4
Total possible SDI-12 sensors	10	10	-	40	40
RS232/422/485 serial sensor port (shared with host communications)	-	-	1	1	1
RS232 serial sensor port (shared with host communications)	1	1	1	1	1
USB port (shared with host communications)	1	-	-	1	1

SDI-12

- Supports SDI-12 protocol versions 1.0 through 1.3 (auto-sensing)
- Measure on Demand and Continuous Measurement modes

- Includes facility for directly interrogating sensors for diagnostic purposes

Generic Serial Sensor Channel

- Allows data to be logged from a wide range of smart sensors and data streams.
- Flexible poll string generation and response parsing
- Supports polled or unsolicited data
- Includes facility for directly interrogating sensors for diagnostic purposes

Data Manipulation and Logging

Calculated Channels

- Combine values from analog, digital and serial sensors using expressions involving variables and functions.
- Functions: An extensive range of arithmetic, trigonometric, relational, logical and statistical functions are available.

Alarms

- Condition: high, low, within range and outside range, optional time specifier
- Actions: set digital outputs, transmit message, execute any *DT80* command.

Schedules

- Number of schedules: 11
- Schedule types: immediate, continuous, timed, polled, digital/counter/serial event, variable change
- Conditional schedule execution: digital state or variable
- Timed schedule rates: 10ms to days; synchronised to time of day

Data Storage

- Internal memory capacity: 128MB (upgradeable)
- Removable USB 1.1/2.0 full speed memory device (optional accessory)
- Data density: approx. 90,000 data points per megabyte.

Communication Interfaces

Ethernet Port

- Interface: 10BaseT (10Mbps)
- Protocol: TCP/IP

USB Port (not DT82)

- Interface: USB 1.1/2.0 full speed (virtual COM port)
- Protocols: ASCII command, TCP/IP (PPP), Modbus, Serial Sensor

Host RS232 Port

- Speed: 300 to 115200 baud (57600 default)
- Flow Control: Hardware (RTS/CTS), Software (XON/XOFF), None
- Handshake lines: DCD, DSR, DTR, RTS, CTS
- Modem support: auto-answer and dial out
- Protocols: ASCII Command, TCP/IP (PPP), Modbus, Serial Sensor

Serial Sensor Port (not DT81/82E)

- Interface: RS232, RS422, RS485
- Speed: 300 to 57,600 baud
- Flow Control: Hardware (RTS/CTS), Software (XON/XOFF), None
- Protocols: ASCII Command, TCP/IP (PPP), Modbus, Serial Sensor

Network (TCP/IP) Services

Uses Ethernet and/or Host/USB/serial sensor (PPP) ports

Command Interface Server

- Allows access to the ASCII command interface via TCP/IP

Web Server

- Configure the *DT80* and access current data and status from a web browser.
- Supported browsers: *Internet Explorer* Version 7 or later, *Mozilla Firefox*, *Google Chrome*, *Apple Safari*
- Custom pages can be defined.
- Download data in CSV format.
- Command interface window.
- Define mimic displays.

Modbus Server

- Access current data and status from any Modbus client (e.g. SCADA system)

Modbus Client (not DT81/82E)

- Poll serial or network Modbus sensors

FTP Server

- Access logged data from any FTP client or web browser

FTP Client

- Automatically upload logged data direct to an FTP server

SNTP Client

- Automatically synchronise system time to NTP server

System

Display and Keypad (not DT81)

- Type: LCD, 2 line by 16 characters, backlight.
- Display Functions: channel data, alarms, system status.
- Keypad: 6 keys for scrolling and function execution.
- Status LEDs: 4 (Sample, Disk, Attention, Power)

Firmware Upgrade

- RS232, Ethernet (FTP), USB or USB disk.

Real Time Clock

- Resolution: 0.2ms
- Accuracy: ±1 min/year (0°C to 40°C), ±4 min/year (-40°C to 70°C)

Power Supply

- External power input: 10 to 30Vdc
- Internal 6V lead acid battery: DT80/81/82I: 1.2Ahr, DT85/85G: 4.0Ah, DT80G/82E/80L/85L: none
- Power output for charging external lead acid battery (*not DT82E/80L/85L)*

Power Consumption

- Peak Power: 12W (12Vdc 1A)
- DT80/81/85 approximate average power consumption (10 analog channels):

Schedule Rate	Ext 12V power consumption	1.2Ah battery life	4.0Ah battery life
1 sec	1400 mW	6 hours	1 day
5 sec	500 mW	1 day	3 days
1 minute	100 mW	10 days	1 month
1 hour	60 mW	3 months	9 months

- DT82E/80L/85L approximate average power consumption (6 analog channels):

Schedule Rate	Ext 12V power consumption
1 sec	950 mW
5 sec	350 mW
1 minute	40 mW
1 hour	10 mW

Physical and Environment

- Construction: Powder coated zinc and anodized aluminium.
- Dimensions: DT80/81: 180 x 137 x 65mm, DT85: 300 x 137 x 65mm
- Weight: DT80/81: 1.5kg, DT85: 2.5kg
- Temperature range: –45°C to 70°C *
- Humidity: 85% RH, non-condensing

* reduced battery life and LCD operation outside range –15°C to 50°C

Accessories Included

- Resource CD: includes software, video training, and user manual.
- USB communications cable (DT80/81/85)
- Ethernet crossover cable (DT82)
- Line adaptor: 110/240Vac to 15Vdc, 800mA

CEM20 Specifications

Interfaces

- Power/Control inputs: 12Vdc, ground, serial data, serial clock (from logger or previous CEM20)
- Power/Control outputs: 12Vdc, ground, serial data, serial clock (to next CEM20)
- Analog output: (to logger channel corresponding to CEM20 address)
- 20 x 4-wire analog inputs

Connections

- Max total cable length between data logger and furthest CEM20: 100m
- Max supported CEM20 units per data logger:
  DT80 & DT80G (Series 2 only): 5
  DT85 & DT85G (Series 2 only): 15

Sampling

- Type: Relay multiplexer
- Maximum Input Voltage: 30Vdc
- Maximum Sampling Speed: 12Hz
- Internal RTD reference junction sensor for thermocouple measurements

System

- Status LED: Sample activity
- Address Selection: 4-way DIP switch. Address 1-15

Power Supply

- Recommended: Logger's switched 12V output
- Alternative: External regulated 12Vdc ± 5%

Power Consumption

- Sampling: 0.36W (12V 30mA)
- Idle: 0.01W (12V 1mA).

Note that in most cases idle power consumption will be zero because the *DT80*'s 12V output will be turned off when not sampling.

Physical and Environment

- Construction: Powder coated steel and anodized aluminium
- Dimensions: 180 x 100 x 50mm
- Weight: 0.55kg
- Temperature Range: -45°C to 70°C
- Humidity: 85% RH, non-condensing

Accessories Included

- Analog and power/control cables for connection to the *DT80*

Command Summary

The following table lists all **commands** supported by the *DT80*. It does not include:

- channel definitions *(P28)*
- schedule definitions *(P44)*
- alarm definitions *(P76)*

Command	Description	Page
'*comment text*	comment, remainder of line is ignored by *DT80*	57
*****	repeat last immediate schedule	51
/*switch*	set switch on (uppercase) or off (lowercase)	203
//	set all switches to their power-on default values	203
?ALL	return current values of all alarm tests	84
?*n*	return current value of alarm *n*'s test	84
?*sched*	return current value of all alarm tests for schedule *sched*	84
BEGIN	clear current job and begin entry of a new job called **UNTITLED**	56
BEGIN "*jobname***"**	clear current job and begin entry of a new job called *jobname*	56
CATTN	clear **Attn** LED	113
CERRLOG	clear error log	213
CEVTLOG	clear event log	213
CHARAC	return characterisation report	214
CHARAC*n*	return line *n* of characterisation report	214
CLOSEDIRECTPPP	manually close PPP connection on host RS232 port	198
COPY *srcfile destfile*	copy file *srcfile* to *destfile*	106
COPYD *option=value option=value..*	unload data from the specified store file to various destinations in various formats	94
CURJOB	return name of current job	58
DEL *file*	delete file *file*	106
DELALLJOBS	delete program text, archive files, logged data and alarms for all jobs	102
DELD *option=value option=value..*	delete logged data	101
DELJOB *jobspec*	delete program text and archive files for specified job(s)	58
DELONINSERT	delete **ONINSERT.DXC** for this *DT80* from USB memory device	59
DELONINSERTALL	delete global **ONINSERT.DXC** from USB memory device	59
DELTREE *dir*	delete directory *dir* and any subdirectories	106
DELVIDEOS	delete all video tutorials	138
DIAL	commence modem dialling	178
DIR	return directory listing for **B:**	106
DIR *dir*	return directory listing for *dir*	106
DIRJOBS	return a list of all stored jobs	58
DIRTREE *dir*	return directory listing for *dir* and all subdirectories	106
DT=[*dtISO***]**	set *DT80* system date/time to *dtISO*	207
EAA	return *DT80* Ethernet adapter address (MAC address)	182
END	complete definition of new job	56
ENDSSDIRECT	cancel SSDIRECT mode	286
FACTORYDEFAULTS	reset all settings to factory default values	211
FORMAT A:	clear and re-format entire file system on USB memory device	106
FORMAT B: DELETEALL	clear and re-format entire file system on internal flash drive	106
G	start all schedules in current job	54
G*sched*	start all schedules in schedule *sched* in current job	54

Command	Description	Page
H	halt all schedules in current job	54
H*sched*	halt all schedules in schedule *sched* in current job	54
HANGUP	terminate active modem connection	178
HELP	list available help topics	18
HELP *topic*	display quick reference information on specified topic	18
HRESET	generate a hardware reset of the *DT80*	210
INIT	clear current job and reset settings to power-on defaults	210
IP	return *DT80* IP address	182
IPGW	return default gateway IP address	182
IPSN	return subnet mask	182
LISTD *option=value option=value..*	return store file details	90
LOCKJOB *jobspec*	prevent specified job(s) from being overwritten when a new job is entered	58
LOG "*string***"**	save a user specified message to the event log	213
LOGOFF	switch off data/alarm logging for all schedules	86
LOGOFF*sched*	switch off data/alarm logging for schedule *sched*	86
LOGON	switch on data/alarm logging for all schedules	86
LOGON*sched*	switch on data/alarm logging for schedule *sched*	86
NAMEDCVS	return current values of all named channel variables	64
NTP	attempt to set time from NTP server	209
P*n*	return the current value of parameter *n*	200
P*n***=***value*	set parameter *n* to *value*	200
PASSWORD	return 1 if a comms interface password is set, otherwise 0	161
PASSWORD="*password***"**	set comms interface password	161
PAUSE *value*	delay for *value* ms	82
PH	return current host RS232 port parameters	170
PH=*baudrate***,***databits***,***parity***,***stopbits***,** *flow*	set host RS232 port parameters (all parameters are optional)	170
PROFILE	return current settings for all profile keys	204
PROFILE *section*	return current settings for all profile keys in *section*	204
PROFILE *section key*	return current value of specified profile key	204
PROFILE *section key***=**	set specified profile key to default	204
PROFILE *section***=**	set all profile keys in section to defaults	204
PROFILE *section key***=***keystring*	set specified profile key to *keystring*	204
PS	return current serial sensor port parameters	174
PS=*mode***,***baudrate***,***databits***,***parity***,** *stopbits***,***flow*	set serial sensor port parameters (all parameters are optional)	174
Q	terminate an unload	100
RAINFLOW:*maxcyc***:***rej%***:***m***..***n***IV**	return a rainflow analysis report	73
REMOVEMEDIA	stop using a USB memory device so it can be safely removed	106
RESET	(obsolete) same as **INIT**	210
RUNJOB "*jobname***"**	replace current job with specified job	57
RUNJOBONINSERT "*jobname***"**	create **ONINSERT.DXC** for this *DT80* on USB memory device	59
RUNJOBONINSERTALL "*jobname***"**	create global **ONINSERT.DXC** on USB memory device	59
S*n***=***a***,***b***,***c***,***d***"***units***"**	define span #*n* (all parameters other than *a* and *b* are optional)	60
SATTN	set **Attn** LED	113
SDI12SEND *sdi-chan* **"***sdi-cmd***"**	send the specified SDI-12 command	273
SERVICEDATA *{filename}*	generate service report; optionally write to specified file	214
SETDIALOUTNUMBER "*phonenum***"**	set the number to call when **DIAL** command is issued	178
SETMODBUS *channels format scaling*	define data formats used when communicating with Modbus client system	153
SHOWPROG *jobspec*	return the program text for the specified job(s)	58

Command	Description	Page
SIGNOFF	end comms session (password required to reconnect)	161
HRESET	(obsolete) same as **HRESET**	210
SSDIRECT *port* **"***terminator***"**	forward all subsequent commands, terminated by specified string, to serial channel port (1=serial sensor, 2=host RS232)	286
STATUS	return a status report	213
STATUS*n*	return line *n* of the status report	213
STATUS14 **"***jobname***"**	return internal details about specified job	213
T*n***=***a***,***b***,***c***"***units***"**	define thermistor scaling function #*n* (all parameters other than *a* are optional)	61
TEST	return a test report	212
TEST*n*	return line *n* of the test report	212
TYPE *file*	return contents of a text file	106
UERRLOG	return contents of error log	213
UEVTLOG	return contents of event log	213
UNLOCKJOB *jobspec*	allow specified job(s) to be overwritten when a new job is entered	58
X	trigger schedule X	51
X*sched*	trigger schedule *sched*	49
Y*n***=***a***,***b***,***c***,***d***,***e***,***f***"***units***"**	define polynomial function #*n* (all parameters other than *a* are optional)	61

a, *b*, *c*, *d*, *e*, *f*	a floating point value
actions	command(s) to execute when function menu item selected (max 256 characters)
dir	a directory name including drive and full path
drive	• **A:** (USB memory device), or • **B:** (internal file system)
fromISO, *toISO*, *dtISO*	date/time in ISO format (*yyyy***/***mm***/***dd***,***hh***:***mm***:***ss***.***sss* or *yyyy***-***mm***-***dd***T***hh***:***mm***:***ss***.***sss*), all time fields are optional
jobname	a job name (max 8 characters)
jobspec	• ***** (all jobs stored on internal file system), or • **"***jobname***"** (the specified job), or • nothing (the current job)
keystring	value of profile key (max 80 characters)
label	label to display in LCD function menu (max 16 characters)
m, *n*, *value*	an integer
maxcyc, *rej%*	rainflow analysis parameters
mode, baud, databits, parity, stopbits, flow	comms port parameters
password	comms interface password (max 10 characters)
phonenum	string of digits or other characters accepted by modem **ATD** command
sched	a schedule identifier: **A-K** or **X**
sdi-chan	SDI-12 channel number (**5-8**)
sdi-cmd	SDI-12 command (max 29 characters)
section, *key*	profile section and key names (max 80 characters)
srcfile, *destfile*, *file*	a file name including drive and full path
switch	a letter **A-Z** or **a-z**
units	units string to use for scaled channels (max 7 characters)

Table 15: DT80 Command Summary

Note that the spaces shown between commands and parameters are generally optional, e.g. **BEGIN"LUPIN"** and **BEGIN "LUPIN"** are equivalent.

If multiple commands are specified on one line they should normally be separated by semi-colons (**;**), e.g.:

```
U; PAUSE 5000; LOGONA
```

although these may be omitted if the result is unambiguous, e.g.:

```
GA GB GC LOGONA
```

ASCII-Decimal Tables

Decimal	ASCII	Control	Description	Decimal	ASCII	Description	Decimal	ASCII	Description	Decimal	ASCII	Description
0	NUL		null	**32**		space	**64**	**@**		**96**	**`**	backquote
1	SOH	**^A**		**33**	**!**		**65**	**A**		**97**	**a**	
2	STX	**^B**		**34**	**"**	dbl quote	**66**	**B**		**98**	**b**	
3	ETX	**^C**		**35**	**#**		**67**	**C**		**99**	**c**	
4	EOT	**^D**		**36**	**$**		**68**	**D**		**100**	**d**	
5	ENQ	**^E**		**37**	**%**		**69**	**E**		**101**	**e**	
6	ACK	**^F**	acknowledge	**38**	**&**		**70**	**F**		**102**	**f**	
7	BEL	**^G**	bell	**39**	**'**	quote	**71**	**G**		**103**	**g**	
8	BS	**^H**	backspace	**40**	**(**		**72**	**H**		**104**	**h**	
9	HT	**^I**	tab	**41**	**)**		**73**	**I**		**105**	**I**	
10	LF	**^J**	line feed	**42**	*****		**74**	**J**		**106**	**j**	
11	VT	**^K**	vertical tab	**43**	**+**		**75**	**K**		**107**	**k**	
12	FF	**^L**	form feed	**44**	**,**	comma	**76**	**L**		**108**	**l**	
13	CR	**^M**	carriage return	**45**	**–**	dash	**77**	**M**		**109**	**m**	
14	SO	**^N**		**46**	**.**	period	**78**	**N**		**110**	**n**	
15	SI	**^O**		**47**	**/**	slash	**79**	**O**		**111**	**o**	
16	DLE	**^P**		**48**	**0**		**80**	**P**		**112**	**p**	
17	DC1	**^Q**	XON	**49**	**1**		**81**	**Q**		**113**	**q**	
18	DC2	**^R**		**50**	**2**		**82**	**R**		**114**	**r**	
19	DC3	**^S**	XOFF	**51**	**3**		**83**	**S**		**115**	**s**	
20	DC4	**^T**		**52**	**4**		**84**	**T**		**116**	**t**	
21	NAK	**^U**	negative acknowledge	**53**	**5**		**85**	**U**		**117**	**u**	
22	SYN	**^V**		**54**	**6**		**86**	**V**		**118**	**v**	
23	ETB	**^W**		**55**	**7**		**87**	**W**		**119**	**w**	
24	CAN	**^X**		**56**	**8**		**88**	**X**		**120**	**x**	
25	EM	**^Y**		**57**	**9**		**89**	**Y**		**121**	**y**	
26	SUB	**^Z**		**58**	**:**	colon	**90**	**Z**		**122**	**z**	
27	ESC		escape	**59**	**;**	semicolon	**91**	**[**		**123**	**{**	
28	FS			**60**	**<**		*92*	****	backslash	**124**	**|**	
29	GS			**61**	**=**		**93**	**]**		**125**	**}**	
30	RS			**62**	**>**		**94**	**^**	caret	*126*	**~**	tilde
31	US			**63**	**?**		**95**	**_**	underline	*127*	DEL	delete

*Table 16: Standard ASCII Characters – **boldface** indicates LCD-displayable characters*

This table lists the standard ASCII character set. The printable characters (codes 32-126) may be directly included in a *DT80* program.

For **text strings** enclosed by **""** within a *DT80* program (e.g. channel name, profile settings, alarm action text, etc. – but not file names), printable or non printable characters may also be entered using the "control character" notation (e.g. **^M** for carriage return) or by entering a backslash followed by the decimal character code (e.g. **\013** for carriage return, **\034** for double quotes). Use **^^** or **** to insert a single **^** or **** character.

Note that if *DeTransfer* is used to send the command to the *DT80*, all backslashes must be entered as **** so that they are not interpreted by *DeTransfer*. So to output a single **** in an alarm string you would need to enter e.g.

```
DO"hello\\\\there"
```

in the *DeTransfer* send window.

Decimal	ASCII	Description	Decimal	ASCII	Description	Decimal	ASCII	Description	Decimal	ASCII	Description
128	**€**		*160*		not used	*192*	**À**		*224*	**à**	
129		not used	*161*	**¡**		*193*	**Á**		*225*	**á**	
130	**‚**		*162*	**¢**		*194*	**Â**		*226*	**â**	
131	**ƒ**		*163*	**£**		*195*	**Ã**		*227*	**ã**	
132	**„**		*164*	**¤**		*196*	**Ä**		*228*	**ä**	
133	**…**		*165*	**¥**		*197*	**Å**		*229*	**å**	
134	**†**		*166*	**¦**		*198*	**Æ**		*230*	**æ**	
135	**‡**		*167*	**§**		*199*	**Ç**		*231*	**ç**	
136	**ˆ**		*168*	**¨**		*200*	**È**		*232*	**è**	
137	**‰**		*169*	**©**		*201*	**É**		*233*	**é**	
138	**Š**		*170*	**ª**		*202*	**Ê**		*234*	**ê**	
139	**‹**		*171*	**«**		*203*	**Ë**		*235*	**ë**	
140	**Œ**		*172*	**¬**		*204*	**Ì**		*236*	**ì**	
141		not used	*173*	**-**		*205*	**Í**		*237*	**í**	
142	**Ž**		*174*	**®**		*206*	**Î**		*238*	**î**	
143		not used	*175*	**¯**		*207*	**Ï**		*239*	**ï**	
144		not used	**176**	**°**		*208*	**Ð**		*240*	**ð**	
145	**‘**		*177*	**±**		*209*	**Ñ**		*241*	**ñ**	
146	**’**		*178*	**²**		*210*	**Ò**		*242*	**ò**	
147	**"**		*179*	**³**		*211*	**Ó**		*243*	**ó**	
148	**"**		*180*	**´**		*212*	**Ô**		*244*	**ô**	
149	**•**		**181**	**µ**		*213*	**Õ**		*245*	**õ**	
150	**–**		*182*	**¶**		*214*	**Ö**		*246*	**ö**	
151	**—**		*183*	**·**		*215*	**×**		*247*	**÷**	
152	**˜**		*184*	**¸**		*216*	**Ø**		*248*	**ø**	
153	**™**		*185*	**¹**		*217*	**Ù**		*249*	**ù**	
154	**š**		*186*	**º**		*218*	**Ú**		*250*	**ú**	
155	**›**		*187*	**»**		*219*	**Û**		*251*	**û**	
156	**œ**		*188*	**¼**		*220*	**Ü**		*252*	**ü**	
157		not used	*189*	**½**		*221*	**Ý**		*253*	**ý**	
158	**ž**		*190*	**¾**		*222*	**Þ**		*254*	**þ**	
159	**Ÿ**		*191*	**¿**		*223*	**ß**		*255*	**ÿ**	

*Table 17: Extended ASCII Characters - Windows CodePage 1252 / ISO-8859-1 (Latin1) – **boldface** indicates LCD-displayable characters*

This table lists an "extended ASCII" character set. Any of these characters may be directly included in a *DT80* program, e.g. by using a non-US keyboard mapping, or by holding down ALT and typing the 4-digit character code (e.g. ALT-0197 for the Angstrom symbol).

Within text strings enclosed in **""**, you can also use the backslash notation (e.g. **\176** for a degree symbol).

Note that many different character sets have been defined for the "extended ASCII" character codes (128-255). The character set shown above is the one most commonly used on Windows based computers, but be aware that some of these characters may appear differently or not appear at all, depending on the application program and font used to display them.

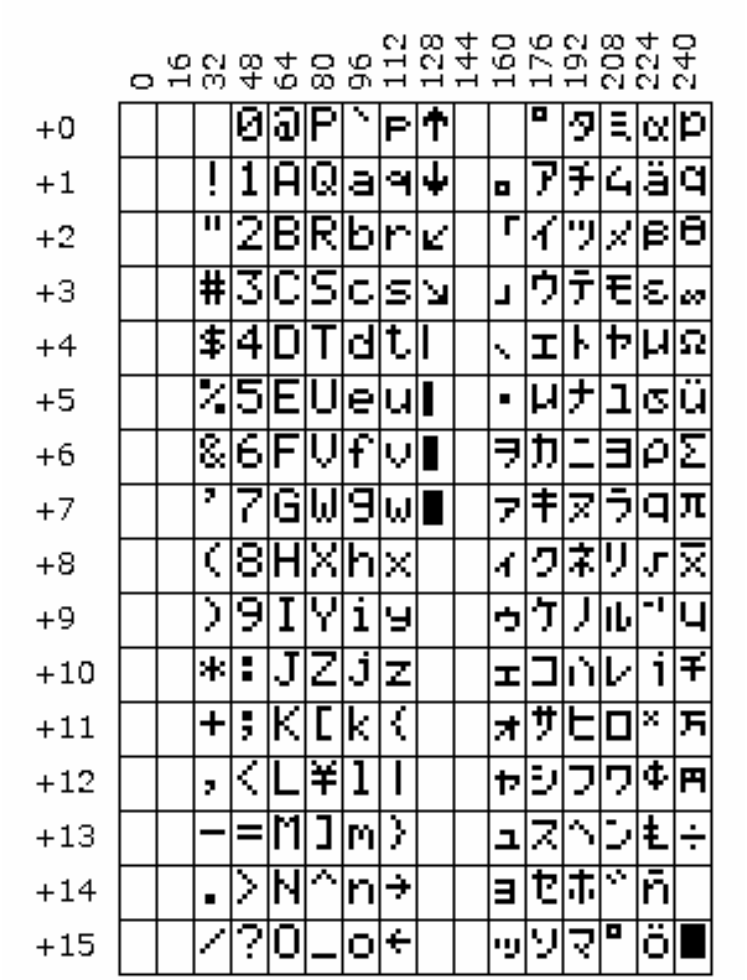


Table 18: LCD Character Set

This table lists the characters that can be displayed on the *DT80*'s LCD. Note the differences between this character set and the previous set. Thus to display a sigma symbol (**Σ**) on the LCD you would use **\246** (240+6) in an alarm text or channel name/units string.

Note that the *DT80* automatically translates the standard units strings degC, degF, degR and Ohm to **°C**, **°F**, **°R** and **Ω** when displaying on the LCD.

RS-232

Signals

The following table lists the standard RS-232 pinouts for both 9-pin (DE-9) and 25-pin (DB-25) DCE and DTE interfaces. Normally the DTE (*DT80*, computer) device's connector is male and the DCE (modem) device's connector is female.

Signal	Function	Direction	DE-9 Pin	DB-25 Pin
DCD	Data Carrier Detect	DTE ← DCE	1	8
RXD	Receive Data	DTE ← DCE	2	3
TXD	Transmit Data	DTE → DCE	3	2
DTR	Data Terminal Ready	DTE → DCE	4	20
GND	Signal Ground		5	7
DSR	Data Set Ready	DTE ← DCE	6	6
RTS	Request To Send	DTE → DCE	7	4
CTS	Clear To Send	DTE ← DCE	8	5
RI	Ring Indicator	DTE ← DCE	9	22

Table 19: RS-232 Pinouts

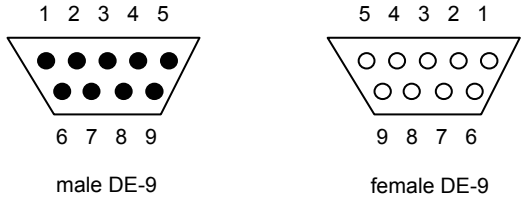


Figure 137: RS-232 pin numbering

Cables

Host Port null modem cable

For applications where a DTE is connected to another DTE (e.g. a *DT80* is connected to a host computer):

- the RXD and TXD signals must be "crossed over" so that one device's TXD is connected to the other device's RXD.
- The "Request To Send" output changes its meaning to "Clear To Send Output" (i.e. a device sets it active when it is able to receive data). This allows hardware flow control to operate in both directions.
- DCD, DTR, DSR and RI are not normally used.

The following cable (dataTaker product code **IBM-6**) is used to connect a PC serial port to the *DT80* host RS232 port. The cable is terminated by a female DE-9 connector at each end. The wiring is symmetrical, i.e. the cable can be connected either way around.

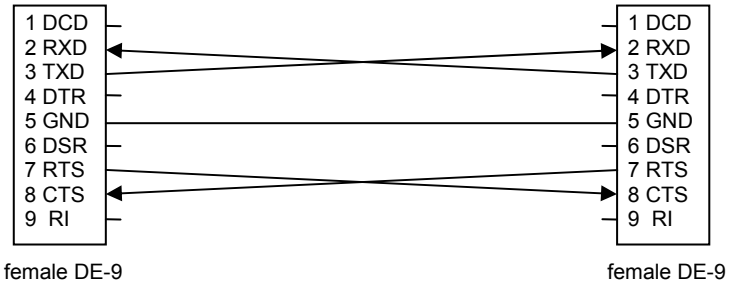


Figure 138: RS-232 null modem cable (IBM-6)

Host Port modem cable

If a DTE is connected to a DCE then a "straight-through" cable is used. The following cable (dataTaker product code **MOD-6**) is used to connect between the *DT80* host port and a modem.

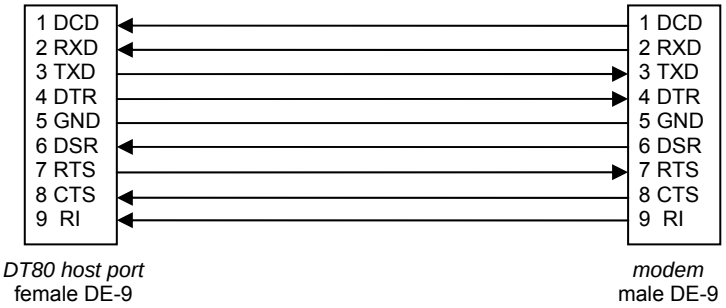


Figure 139: RS-232 modem cable (MOD-6)

Serial Sensor Port null modem cable

The following cable (dataTaker product code **CAB-015**) is used to connect a PC to the *DT80* serial sensor port. This cable is also often used to connect the dataTaker *CANgate* product to the serial sensor port.

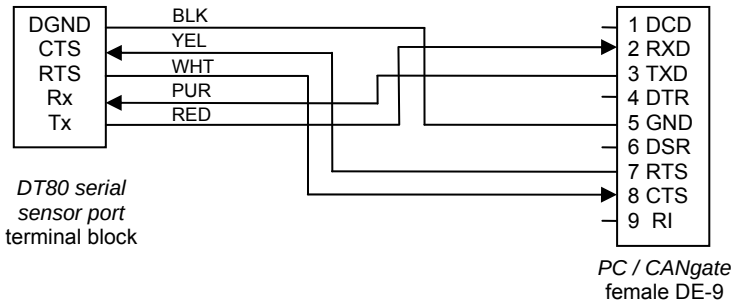


Figure 140: serial sensor RS-232 null modem cable (CAB-015)

Note This cable is only applicable if the serial sensor port mode is set to RS232.

Upgrading DT80 *Firmware*

The *DT80*'s "operating system" (or **firmware**) is stored in the *DT80*'s Flash memory. This means that you can easily upgrade your *DT80*'s firmware:

- using a USB memory device, or
- from a host computer running *DeTransfer*, or
- using an FTP client

It is strongly recommended that you keep your *DT80* up-to-date with the latest firmware. Firmware files are available for free download from www.datataker.com in the Support/Downloads area.

The same firmware is used for all *DT80* series products (DT80, DT80G, DT81, DT85 and DT85G). The firmware upgrade file is named according to its firmware version number – for example, **DT80-8040001.zip** is DT80/81/85 firmware Version 8.02.0001 (normally referred to as just "8.04").

Two different firmware packages are available:

- The standard package (**DT80-8040001.zip**) is suitable for Series 2 loggers
- For Series 1 loggers, use **DT80-8040001-series1.zip**. This contains the same firmware, but the files relating to the enhanced web interface are not included, as it is not supported on Series 1 loggers.

The above packages are suitable for upgrade using a connected computer running *DeTransfer.*

Packages are also available for upgrade via USB memory device or FTP. These files have a **–usbdisk** suffix, e.g. **DT80-8040001-usbdisk.zip**.

Important All firmware packages include **release notes**, which describe the changes made in the release and other information. Always check the release notes for any changes to the upgrade procedure documented here.

Recommended Preparation

In most cases a firmware upgrade can be performed without disturbing the *DT80*'s settings or logged data, although the job will need to be reloaded if it is not an ONRESET job. If any special procedures are required, these will be detailed in the firmware release notes.

It is recommended, however, that you carry out the following procedure before upgrading the *DT80*'s firmware to ensure that nothing is lost in the event of a problem during the upgrade.

1. Connect to the *DT80* using *dEX* or *DeTransfer*.
2. Save any previously logged data stored in the *DT80*'s internal memory by unloading it to the host computer or copying to a USB memory device.
3. In the *dEX* web interface, note any important profile settings, such as Ethernet IP Address. If you are using *DeTransfer* or other terminal software, you can issue the **`PROFILE`** command to return the current profile settings.
4. Power the logger from an external supply, and ensure that the internal battery is connected and is fully charged.
5. Verify that there is sufficient free space on the *DT80*'s internal flash disk, as described below.

You are now ready to perform the firmware upgrade.

Note If you have previously used the *DT80* web interface then it is recommended that you clear your web browser's cache to ensure that after the upgrade you are running the correct version of the web interface. (The browser cache, also referred to as "temporary internet files", holds copies of downloaded files on the computer's hard disk.)

Free Disk Space

As part of the firmware upgrade process, files may be installed on to the internal flash disk (B:). It is therefore necessary to ensure that there is sufficient free space on this drive before starting the upgrade. To check the free space, type **`DIR "B:"`** in *DeTransfer*, or use the **Storage** status screen in the enhanced web interface.

The standard and Series 1 firmware packages install approximately 10MB of files. If these files do not already exist then 10MB of free space will be required.

Note When upgrading using a USB memory device or FTP, a temporary copy of the installation files is made on the internal flash disk. This means that a minimum of 10MB free space is required during installation, or double this if the files do not already exist on the logger.

Firmware Upgrade – USB Flash Device

The simplest way to upgrade the *DT80* firmware is by using a USB memory device. This is also convenient if you have several loggers to upgrade.

1. Obtain the appropriate firmware upgrade zip file from www.datataker.com or your Datataker representative. This file should have a **–usbdisk** suffix.
2. Extract all files from the zip file into the root directory of a USB memory device.
3. Ensure that the *DT80* is powered up and awake, then Insert the USB memory device into the logger. The **oninsert.dxc** file on the USB device will then run. This will:
   a) copy the firmware upgrade files to the *DT80* internal memory (during this time the green Disk LED will flash), then
   b) start the firmware upgrade, which will proceed in a similar way to the RS232/USB method.
4. The logger will automatically restart once the upgrade is complete.
5. Check the firmware version displayed on the LCD, or send the TEST0 command.

Firmware Upgrade – Host USB or RS232 Port

Here's the procedure for upgrading the firmware of a *DT80* by using *DeTransfer* (Version 3.18 or later) on a computer directly connected to the *DT80*'s USB or Host RS-232 port.

The firmware upgrade procedure is as follows:

1. Obtain the appropriate firmware upgrade zip file from www.datataker.com or your Datataker representative. This file should not have a **–usbdisk** suffix. Extract all files from the zip file.
2. Review the release notes (which were in the zip file). These identify the changes that have been made to the firmware, may dictate a change to the upgrade procedure described here.
3. Connect the host computer to the *DT80* using USB. RS232 may also be used (57600 baud, 8 data bits, no parity, 1stop bit)

   Start *DeTransfer*.
4. If you are using USB then the *DtUsb* driver software will need to be disabled in order to make the USB virtual COM port available to *DeTransfer*. Open the *DtUsb* GUI by double clicking on the purple system tray icon, or selecting **DtUsb** in the Windows start menu. Then click **Quit** to shut down *DtUsb.*
5. In *DeTransfer:*
   a) Open a connection to the *DT80*
   b) Choose **Upgrade Firmware (DT80/800)** from the File menu.
   c) Select the correct firmware file, then press OK
6. The upgrade process will now proceed automatically. The *DT80*'s LEDs will flash and the LCD display should indicate that the upgrade is progressing. You will notice that the upgrade proceeds through three phases:
   a) A special "loader" program is downloaded to the logger (**Attn** LED flashes and display shows: `DT8x Bootstrap`)
   b) The main firmware package is downloaded to the logger (**Sample** LED flashes and display shows: `DT8x Loader`). This package normally consists of a number of files (which are installed onto the internal B: drive), followed by the firmware proper (which is installed into a special area of flash memory).

      Note If one or more of the files in the firmware package cannot be installed onto the *DT80*'s internal drive (e.g. due to insufficient disk space) then an error message (e.g. `fwrite: Cannot write data`) will be returned to the host computer and the *DT80* will restart. The firmware version will not have changed. Press the **Details** button on the firmware upgrade window to see status and error messages returned by the logger.
   c) A hard reset is performed (display shows the normal "sign-on" screen)

   Important During the upgrade, do not remove any cables, or reset or power-down the *DT80*.
7. Once the upgrade is complete, check that the version number displayed on the sign-on screen is correct. For example if the file **DT80-8040001.dxf** was loaded then the display should indicate `DT80 V8.04`.
8. Connect to the *DT80* and re-load the required job if required.

   The upgraded *DT80* is now ready for use.

Firmware Upgrade – Remote TCP/IP

The following method can be used to upgrade a *DT80* via a remote TCP/IP connection (Ethernet or PPP).

1. Obtain the appropriate firmware upgrade zip file from www.datataker.com or your Datataker representative. This file should have a **–usbdisk** suffix.
2. Extract all files from the zip file into a convenient temporary folder.
3. Load the *dEX* web interface and open the command window. Alternatively, run *DeTransfer* and make a TCP/IP connection to the logger.
4. Connect to the logger using an FTP client. For example, enter
   ftp://*username*:*password*@*ip-address*
   into the address bar of Windows Explorer (where *username* and *password* are the logger's configured FTP username and password, and *ip-address* is the logger's IP address).

   You should see the contents of the root directory of the logger's internal drive (B:), which will normally contain **EVENTS**, **INI** and **JOBS** folders, along with a file called **FAILSAFE**.
5. Upload the **LOADER.S** and **FIRMWARE.BIN** files (which you extracted from the zip file) into the logger's root directory (e.g. by dragging them from the temporary folder where you saved them).
6. Refresh the FTP view to confirm that the files are present. Close the FTP client.
7. In the *dEX* or *DeTransfer* send window, type **!BOOTIT** and press Enter. The upgrade will now start.
8. Disconnect from the logger in *dEX* or *DeTransfer*, wait 10 minutes, then re-connect.
9. Verify the new firmware version by sending TEST0

Reverting Back to Old Firmware

The above procedures can also be used to revert back to an earlier version of the firmware, should that be required. The resource CD shipped with the logger contains a copy of the original firmware that was installed on the *DT80*. Contact *dataTaker* support if you need to obtain an installation file for any other non-current firmware version.

In Case of Failed Upgrade

In the unlikely event that something goes wrong during an upgrade (e.g. power to the *DT80* or host computer is lost, or the firmware file is corrupted), use the following recovery procedure.

1. Reset the *DT80* by inserting a paper clip or similar into the reset hole (*Figure 80* *(P216)*)
2. If the old firmware starts correctly, simply repeat the above upgrade procedure.
3. If the firmware does not start correctly (i.e. the normal sign-on display is not shown and the *DT80* does not respond to commands, or the *DT80* continuously resets) then hold down the **Edit/OK** key and reset the *DT80*. The **Attn** LED should now be flashing slowly (5s on, 5s off) and the display should show **DT80 Bootstrap**. Release the **Edit/OK** key.
4. At this point you should now be able to repeat the above upgrade procedure using the USB/RS232 method.

If the upgrade repeatedly fails to complete then click the **Details** button during the upgrade and check for error messages in the small text window that appears. It is possible that there is insufficient free space on the internal B: drive, for example.

Error Messages

Standard Messages

The *DT80* returns a message when it detects an error in a command, or an operational difficulty. The form of the error report is controlled by the **/U** switch. The default is the verbose form shown in the table below. If the switch is set to **/u** the error message is reduced to an error number (e.g. E3). (Note this Switch also reduces the verbosity of other returned data).

Error messages can be switched off by the **/m** switch. The default is for errors to be reported (**/M**). During an unload operation, error reporting is disabled until the unload is complete.

If an error is detected during job entry (i.e. between **BEGIN** and **END**) then the remainder of the job is ignored.

The table below lists all of the *DT80* errors, along with an explanation of their likely cause and/or correction.

Error Number and Description Cause/Action	Error Category				
	Syntax	Operation	Memory	Reading	Hardware
E1 – Time set error • Must be in format defined by P39 and P40 • Illegal separator or non-digits entered	☑				
E2 – Command line too long • Command too long (maximum 250 characters)		☑			
E3 – Channel option error • Illegal channel option used • Incompatible options used • Option invalid for channel type	☑				
E7 – Day set error • Illegal day number entered	☑				
E8 – Parameter read/set error • Parameter index out of range • Parameter value out of range	☑				
E9 – Switch error • Illegal switch command character	☑				
E10 – Command error • Unrecognised keyword	☑				
E12 – Channel list error • Channel number outside the legal range • Incomplete channel sequence • Invalid channel type • Polynomials or spans index out of range	☑				
E18 – STATUS command error • STATUSn outside the range 1 to 14	☑				
E23 – Scan schedule error • Schedule ID not A-K, X or S • Scan time interval too large • Scan interval type invalid • Event or counter channels invalid	☑				
E25 – Channel table full • Internal acquisition and alarm table filled (maximum 1000 entries). Additional channels cannot be declared			☑		
E29 – Poly/span declaration error • Polynomial or span index out of range (1 to 50) • Individual terms not separated by a comma • Range of terms outside 1.0e–18 to 1.0e18	☑				
E30 – Analog measurement fault • Faulty circuit board, circuit board connector, or circuit board power supply					☑

Error Number and Description Cause/Action	Error Category Syntax	Operation	Memory	Reading	Hardware
• If fault persists after a hard reset contact your Datataker representative.					
E32 – Job not found • The named job cannot be found.	☑				
E37 – No current job • A command was entered that operates on the current job, but there is no job currently loaded.	☑				
E39 – Channel list fixed /F • Changes to program are not allowed		☑			
E42 – USB device not ready • No USB memory device inserted • *DT80* has not yet read the required system information from the device (wait a few seconds) • USB device is faulty or not a memory device		☑			☑
E49 – Job has logged data/alarms • A job that has logged data cannot be deleted. Delete the data first.		☑			
E50 – Job locked • A job that has been locked cannot be modified		☑			
E51 – ALARM/IF command error • Setpoint character <, >, <> or >< missing • AND, OR, XOR incorrectly entered • Setpoint not specified or too large • Delay incorrectly specified	☑				
E52 – Text memory full • Memory for storage of alarm and expression text is full			☑		
E54 – Expression error • Syntax error • Expression too complex	☑				
E65 – ALARM undefined • Alarm n does not exist	☑				
E74 – Serial sensor CTS detect timeout • Serial sensor: CTS did not go to the required state within timeout period				☑	
E75 – Serial sensor transmit timeout • Serial sensor was not able to transmit (e.g. due to flow control state) within the timeout period				☑	
E80 – Serial device not responding • no response received from SDI-12 sensor • check cabling and sensor address				☑	☑
E81 – Serial device invalid response • garbled response received from SDI-12 sensor • check for address conflict • check for electrical noise				☑	☑
E82 – Serial device data not available • SDI-12 sensor doesn't support the requested measurement • sensor doesn't support continuous mode				☑	
E89 – Serial sensor receive timeout • Serial sensor: expected characters were not received within timeout period				☑	
E90 – Serial sensor scan error • Serial sensor: could not convert the received text as specified in the control string				☑	
E101 – Undefined reference: *name* • No channel was found with the specified name	☑				

Error Number and Description Cause/Action	Error Category Syntax	Operation	Memory	Reading	Hardware
E102 – Storefile record size too large • There are too many logged channels in the schedule			☑		
E103 – Invalid storefile: *filename* • The indicated storefile appears to be corrupted		☑			
E104 – Drive format failed • Unable to format the specified drive. It may be write-protected or damaged.		☑			☑
E105 – Invalid PROFILE section/key name • Check spelling of section and key name in PROFILE command	☑				
E106 – Invalid PROFILE value • Check that value being set in PROFILE command is valid	☑				
E107 – Counter is already used as a trigger • The specified counter is already used as a schedule trigger and cannot be used again.		☑			
E109 – File IO error: *detailed description* • An error occurred while reading or writing to a file on one of the drives (A: or B:). The detailed description will contain exact details of the error type. For example, a write-protected file cannot be written to.		☑			
E110 – Error accessing storefile: *detailed description* • An error occurred while reading or writing to a storefile containing logged data. The file may be corrupted.		☑			
E112 – Parameter/option conflict • The specified combination of command parameters or channel options are not valid	☑				
E113 – Schedule option error • Invalid schedule option specified	☑				
E114 – Command parameter error • Invalid parameter specified for a command	☑				
E115 – Serial sensor string error • Invalid syntax within serial sensor control string	☑				
E116 – Cannot log: *detailed description* • The *DT80* cannot log data for one or more schedules for the indicated reason • If the problem was that an existing job of the same name had logged data/alarms then you need to give the new job a different name, or delete the old job's data using DELDATA/DELALARMS		☑	☑		☑
E117 – Incompatible schedule store units and trigger • You can only specify storefile size by time (e.g. 12 hours data) if the schedule trigger is time based.	☑				
E118 – Error accessing drive *x*: *detailed description* • The indicated drive (A: or B:) could not be accessed • Media may be absent, not formatted or faulty.		☑			☑
E119 – No matching storefiles found • There are no storefiles for the specified job/schedule		☑			
E122 – Command incompatible with configured port function • nSERIAL channel or trigger defined, or SSDIRECT command used, and specified serial port has not been configured as a serial channel in the profile		☑			
E123 – SSDIRECT mode already active • SSDIRECT command was issued but SSDIRECT mode is already active on another comms port. Use ENDSSDIRECT to cancel SSDIRECT mode.		☑			

Error Number and Description Cause/Action	Error Category Syntax	Operation	Memory	Reading	Hardware
E124 – Modbus transaction failed • could not establish connection to Modbus slave device, or no response to request		☑			
E125 – Modbus – write attempt to read-only register • Modbus discrete inputs and input registers (types 1 and 3) cannot be written to using an expression	☑				
E126 – Modbus not supported on this channel • Modbus channel should be 1,2,3 or 4	☑				
E127 – Modbus IP address specified on serial channel	☑				
E128 – Modbus serial address specified on TCP/IP channel • or no address specified	☑				
E129 – Modbus – unexpected format of response packet		☑			
E130 – Modbus – unexpected function id in response		☑			
E131 – Modbus – exception response received • slave device does not support the requests used by the *DT80*.		☑			
E132 – Modbus – error in definition of CV block to send • invalid CV index	☑				
E133 – Modbus – reading values to CVs prevents writing • MODBUS channel cannot write values from CVs and also assign to CVs	☑				
E134 – Modbus – 32 bit format not applicable to discrete transfer • MBL, MBF options are not applicable when reading 1-bit registers (coils/discrete inputs)	☑				
E135 – Modbus – volume of data to transfer exceeds Modbus message capacity • limit is 123 16-bit registers or 1968 1=bit registers	☑				

Table 20: DT80 Error Messages

Data Errors

Errors may also occur even though the *DT80*'s measurement system is operating normally – for example if an analog input is out of range or a connected sensor does not perform correctly. In some cases, the *DT80* returns an error message (see "Reading" error category in the above table), but mostly there is no message returned. Instead, the *DT80* flags the logged and/or returned data value as invalid.

Each logged reading has an associated "data state", which identifies whether that particular reading is valid or invalid. The following data states are possible:

Logged data state	Value when unloaded CSV/free format	fixed format	Description
OK	measured value	measured value	No error
Overrange	`OverRange`	`99999.9`	• input voltage exceeds max positive input voltage • input voltage exceeds positive linearization limit for sensor • input frequency too high (**F** channel type)
Underrange	`UnderRange`	`-99999.9`	• input voltage exceeds max negative input voltage • input voltage exceeds negative linearization limit for sensor • input frequency too low (**F** channel type)
Not Yet Set	`NotYetSet`	`-9e9`	• *DT80* analog hardware fault • insufficient samples have been taken to calculate a statistical value • could not read a valid value from a serial device
Reference Error	`RefError`	`8e9`	Thermocouples and some bridges require a separate reference channel measurement as part of the measurement process. This error indicates that although this channel's raw measurement was OK, the associated reference channel measurement was not.
Calculation Error	`Error`	`-8e9`	Maths error such as division by zero

DT80 Abnormal Resets

If a serious internal hardware or firmware failure occurs, the *DT80* will normally force a hardware reset (equivalent to a **HRESET** command). A message will be displayed on the LCD (e.g. **SW Exception**) and the **Attn** LED will flash until a keypad button is pressed.

Additional technical details about the cause of the reset will generally be logged to the *DT80*'s event and error log files. You can view these files using the **UEVTLOG** and **UERRLOG** commands, or via the web interface.

Abnormal resets should never occur, but if you do experience one please **contact Datataker support**. It will assist us if you can provide the following details:

- SERVICEDATA report
- the job that was running at the time
- any other details regarding how the *DT80* is set up (How does the *DT80* communicate with the host? How is it powered? What host application(s) are being used?)
- the circumstances leading up to the failure (How many times has this happened? What was the logger doing immediately prior to the failure?).

Glossary

4–20mA loop

A common industrial measurement standard. A transmitter controls a current in the range of 4 to 20mA as a function of a measurement parameter. Any receiver(s) or indicator(s) placed in series can output a reading of the parameter. Main advantage is 2-wire connection and high immunity to noise pick-up. Usually powered from a 24V supply.

50/60Hz rejection

The most common source of noise is that induced by AC power cables. This noise is periodic at the line frequency. *DT80*s are able to reject most of this noise by integrating the input for exactly one line cycle period (20.0 or 16.7ms).

Ω

ohm, a unit of resistance

µA

microamp, 10^{-6} A

µs

microsecond, 10^{-6} s

µStrain

microstrain, strain expressed in parts per million (ppm). Strain is a measure of the stress-induced change in length of a body.

µV

microvolt, 10^{-6} V

A

Ampere or amp, a unit of current

actuator

A device that converts a voltage or current input into a mechanical output.

ADC

Analog-to-Digital Converter. Part of the *DT80*'s input circuitry that converts an analog input voltage to a digital number (in other words, it converts a smoothly-varying signal to a quantised digital value). The *DT80* is a digital instrument, and therefore requires an ADC to convert analog sensor signals into digital form prior to processing. Important characteristics of an ADC are its linearity, resolution, noise rejection and speed.

ADC settling time

See *channel settling time* (P330).

Ah

Ampere-hour, a unit of electrical charge, often used when referring to battery capacity

analog

a quantity that can vary continuously through a potentially infinite number of values — for example, the time swept out by the hands of a clock, or the output of a thermocouple. Compare with digital.

analog ground

Reference point for the *DT80*'s instrumentation amplifier. This ground is normally isolated from any other ground point so it can "float" up or down to match the common mode voltage of the input. This isolation extends the *DT80*'s common mode voltage limits, and helps prevent ground loops.

ASCII

American Standard Code for Information Interchange. A coding system designed for standardising data transmission to achieve hardware and software compatibility. It assigns a 7-bit code to each of the 128 standard characters: 96 visible characters — letters, numbers and punctuation marks (including the space character); 32 hardware control characters — sounding a bell, advancing a printer page, carriage return, line feed and so on.

asynchronous

Not synchronised, not occurring at pre-determined or regular intervals. A telephone conversation is asynchronous because both parties can talk whenever they like. In an asynchronous communications channel, data is transmitted intermittently rather than in a constant stream.

Auto-IP

A system where a device on a TCP/IP network can, in the absence of a DHCP server, automatically select its own IP address

and other network parameters.

autoranging

The process of changing amplifier gain automatically so that the signal is amplified as much as is possible without exceeding output limits.

base date and time

The *DT80*'s base date is 0:00:00 on 01/01/1989. All timestamps are stored as offsets from this point in time.

bit

The smallest unit of information in a computer. A bit has a single value: either 0 or 1. Computers generally store information and execute instructions in bit-multiples called **bytes**.

brackets and braces

Delimiters:

Delimiter	Function
( ) Round brackets (parentheses)	• identify channel options, e.g. **1V("Flow Rate",Y1)** • group terms within expressions, e.g. **1CV=3.14*(2CV+3CV)** • enclose a time/date value in current format, e.g. **U(11/9/2007,12:03:00)**
[ ] Square brackets	• enclose channel variable to be used within a serial prompt or parse command, e.g. **1SERIAL("%f[17CV]")** • enclose a time/date value in dataTaker ISO or ISO8601 format, e.g. **U[2007/09/11,12:03:00]** or **U[2007-09-11T12:03:00]**
{ } Curly brackets (braces)	• enclose channels and commands to be conditionally executed within **ALARM** and **IF** statements , e.g. **ALARM1(2CV>3){1CV=1CV+1 HB}** • signify output actions in the serial sensor command, e.g. **1SERIAL("{MD004}%f[1CV]")**

bps

bits per second, a measure of data transfer rate

bridge

A sensitive and stable means of measuring small changes in resistances. They are particularly useful when applied to strain gauges (as found in pressure sensors and load cells). See *Bridges* (P242).

buffer

An area of memory where data is held temporarily until the system is ready for it, or in case it is needed in the future.

byte

A unit of information that is eight bits long

Carlson meter

A sensor for measuring strain, which works by detecting the change in resistance of a pair of steel wires.

carriage return (CR)

an ASCII character (code 13 decimal) often used to mark the end of a line of text or a data record.

channel definition

A channel's ID followed by any channel options (in round brackets). See *Figure 7*(P44).

channel ID

A channel's number and type (e.g. **3TK**). See *Components of a typical schedule command* (P44).

channel list

A list of channel definitions within one report schedule.

channel settling time

The time allowed for the input signal to the ADC to stabilise before it is measured. This can be controlled using the measurement delay (MDn) channel option.

channel table

An internal *DT80* data structure that stores details of all defined channels. The channel table is limited to a maximum of 1000 entries.

A channel table entry is used each time a channel is referenced in the current job. For example, the job

```
RA10S T 4V 1CV(W)=1CV+1 ALARM2(1CV>10)"boo"{1DSO=0}
```

uses 5 channel table entries (for **T**, **4V**, **1CV**, **1CV** and **1DSO**).

clock

The *DT80* a real-time clock/calendar, which you can set to your actual time

CMRR

Common-Mode Rejection Ratio. A measure of the influence of common-mode voltage (unwanted) on the output of the *DT80*'s instrumentation amplifier (see common-mode voltage (P331) below).

More precisely, CMRR is the ratio of the common-mode voltage at the amplifier's input to the common-mode voltage at the amplifier's output, expressed in dB. It indicates the quality of a measuring system's input electronics. Relevant to basic (differential) inputs only.

$$CMRR = 20\log\frac{V_{CM}}{V_{out}\cdot A_V}$$

where

V_{CM}	is an applied common-mode voltage
V_{out}	is the resulting output voltage
A_V	is the amplifier's voltage gain

command line

One or more *DT80* commands typed one after the other, separated by tab or space characters, and ending with a return character. Limited to a maximum of 250 characters (including spaces, tabs, underscores,…). For example

```
RA10S T 4V 5TK
```

is a command line made up of four *DT80* commands (separated by spaces).

common-mode voltage

An unwanted AC and/or DC voltage that offsets both inputs to the *DT80*'s instrumentation amplifier (with respect to amplifier ground). It is unwanted because it usually originates from nuisance sources such as electrical noise, DC offset voltages caused by the sensors or the equipment being measured, or from ground loops.

Typically in industrial measurement, the sensor signals you apply to the *DT80*'s input terminals consist of

- the small component you want to measure (a few mV to a few tens of mV), PLUS
- a large unwanted component (a few V to a few tens of V) — the **common-mode voltage**.

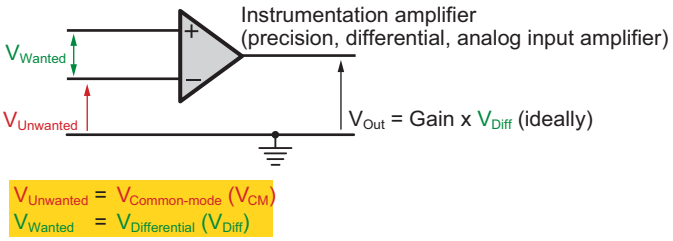


Figure 141: Common-mode voltage VCM and Differential voltage (VDiff) - 1

When the *DT80* makes a measurement, both of these components are applied to the inputs of the its instrumentation amplifier. Then, when configured for basic (differential) use, the amplifier does two things:

- It rejects most of the common-mode voltage (the unwanted signal). How well the amplifier does this is indicated by its common-mode rejection ratio — see *CMRR* (P331).
- It amplifies the difference between the signals on its two inputs. This is the wanted signal and is called the **differential voltage** — see *differential voltage* (P332).

Common-mode voltage is calculated as the average of the voltages between the measurement system's ground and the two input terminals:

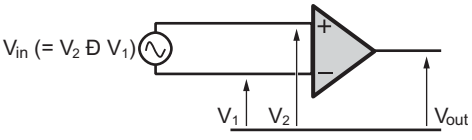


Figure 142: Common-mode voltage VCM and Differential voltage (VDiff) — 2

CR

See *carriage return* (P330).

crest factor

The peak-to-RMS voltage ratio of an AC signal (*Crest factor* (P332)).

A pure sine wave has a crest factor of 1.414. If the crest factor is less than 1.4, the waveform is flattened; if the crest factor is

greater than 1.4, the waveform is peaked.

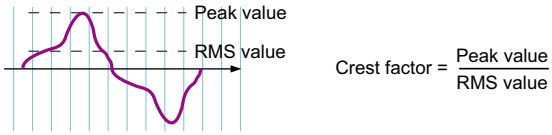


Figure 143: Crest factor

DAC

Digital-to-Analog-Converter

data acquisition system

A measurement system that scans a range of analog and digital channels, converts the readings to digital format, and forwards the data to a host. The host does any storage or data manipulation required. See also logging (P334).

data logging system

A data acquisition system with its own on-board data storage and manipulation facilities. See also logging (P334).

dataTaker

The name of the family of stand-alone data logging, acquisition and associated equipment manufactured by Biolab (Aust.) Pty Ltd trading as Datataker.

dataTaker releases:
1983 *dataTaker* DT100
1987 *dataTaker* DT200
1990 *dataTaker* DT500 series, DT600 series, and the DT50
2000 *dataTaker* DT800
2005 *dataTaker* DT80
2006 *dataTaker* DT81
2007 *dataTaker* DT85
2008 *dataTaker* DT80/81/85 Series 2, DT80G/85G, CEM20

DCE

Data Communications Equipment. A DCE device (a modem, for example) enables a DTE device (such as a computer or a *DT80*) to communicate over phone lines or data circuits. A DCE device connects to the RS-232 interface of a DTE device.

default

An attribute, value or option that is assumed if none is explicitly specified. A state or group of operating conditions (determined by the manufacturer and factory-set) to which the *DT80* automatically reverts after a reset.

DHCP

Dynamic Host Configuration Protocol. A system for automatically setting the IP address and other network parameters for a device on a TCP/IP network.

differential input

An analog input where the difference between two voltages is measured, without reference to ground or any other common point. For example the **1V** command measures the differential voltage between the 1+ and 1- terminals.

differential voltage

The difference between the voltages on the two inputs of the *DT80*'s instrumentation amplifier. See common-mode voltage (P331).

digital

a quantity that is represented by a number that has a finite number of possible values. The number of bits used to store a digital value determines the resolution, i.e. how close two values can be and still be resolved (distinguished). Some quantities are inherently digital, e.g. a logic signal or switch (whose state can be represented by 1 bit)

digital ground

The reference point for most of the *DT80*'s circuits, e.g. power, communications, digital I/O – everything except the analog input sub-system (see *analog ground* (P329)).

direct commands

Commands that perform direct tasks within the *DT80* the moment they are sent (for example, switch, parameter, unload, alarm, job and delete commands).

directory

an area on a data storage device used to store related files. Also known as a *folder*.

DNS

Domain Name Service, a TCP/IP network protocol. Networked devices, such as the *DT80*, send requests to a DNS server

whenever they need to translate a domain name (e.g. **ftp.moose.com.au**) into a numeric IP address (e.g. 203.111.202.44)

DTE

Data Terminal Equipment. The information source and/or destination in an RS-232 communications link. The *DT80*'s Host RS-232 port and Serial Channel are DTE devices, as is a PC's RS-232 port (serial port).

The RS232 standard was originally designed for connecting a DTE to a DCE (e.g. a modem). However, a DTE can also be directly connected to another DTE by means of a null-modem cable

echo

A communications option for commands you send to the *DT80*. When echo is turned on see Table 6: *DT80* Switches (P203), commands you send to the *DT80* are automatically returned to the host computer screen.

Echo is useful for troubleshooting: when the echo is on, you can see by the returned commands that the *DT80* is actually receiving them. (Once you're confident that it is receiving, you can turn the echo off.) Also, any error message appears right under the echo of the erroneous command, making the error obvious.

EEPROM

Electrically-Erasable Programmable Read-Only Memory. A special type of PROM that can be erased by exposing it to an electrical charge. Requires data to be written or erased one byte at a time (compare with Flash (P333) below). Retains its contents even when power is unavailable.

enable

Turn on or activate

Ethernet

A standard method for connecting a network of computers so that they can share information. The *DT80* supports "10 Base-T" Ethernet, that is it operates at a data rate of 10Mbps and uses Twisted-pair cable. See *Ethernet Communications* (P217).

firmware

The "operating system" software stored inside the *DT80*. The *DT80*'s firmware is semi-permanent, and you can upgrade it with a simple file transfer.

Flash

A special type of EEPROM that can be erased and reprogrammed in blocks (instead of one byte at a time — compare with EEPROM (P333) above). Flash memory is therefore much faster to erase and re-write. Retains its contents even when power is unavailable. The *DT80*'s firmware is stored in Flash memory. See also *Upgrading DT80 Firmware* (P321).

flow control

The process of controlling the flow of information between communications devices. For example, if data is being sent too quickly from a *DT80* to its host computer, the computer tells the *DT80* to temporarily stop sending data; then when the computer has caught up, it tells the *DT80* to resume sending data. Hardware handshaking (hardware flow control; RTS/CTS) and software handshaking (software flow control; XON/XOFF) are alternative mechanisms of flow control.

folder

Another name for **directory**

format

A specific way of organising related information. For example, the *DT80*'s internal data memory is formatted as a DOS/Windows compatible file system.

FTP

File Transfer Protocol. A TCP/IP protocol for copying files from one computer to another.

Gray code

A binary numbering system where two successive values differ by only one bit. Rotary or linear position encoders frequently provide Gray-coded outputs to avoid the possibility of erroneous readings due to multiple bits changing not quite simultaneously.

For example, a 3-bit Gray code sequence is 000, 001, 011, 010, 110, 111, 101, 100.

ground

A common return path that is the zero voltage reference level for the equipment or system. It may not necessarily be connected to earth.

ground loops

More often that not, grounds in a measurement system are not at the same electrical potential — differences may be from microvolts to many volts. Then, if signal wires happen to connect different grounds together, currents can flow and result in unpredictable measurement errors. These unintended conduction paths are referred to as **ground loops**. The *DT80* has been designed for maximum immunity to ground loops — see *Ground Loops* (P300).

host computer

The computer you use for supervising the *DT80*

host software

The software you run on the host computer to supervise the *DT80*. See *DT80-Friendly Software* (P15)

hunting

An undesirable oscillation

HWFC

Hardware flow control (RTS/CTS). Also known as **hardware handshaking**. See flow control (P333).

A device using hardware flow control monitors its Clear To Send (CTS) input and will not send data until the signal is active. Conversely, a device indicates that it can receive data by driving its RTS output active (which is then connected to the other device's CTS input)

Hz

Hertz, a unit of frequency

instrumentation amplifier

A precision differential amplifier for amplifying the *DT80*'s analog input signals (wanted) and rejecting any common-mode voltage (unwanted).

IP address

A device's address on a TCP/IP Ethernet network. Every device connected to an Ethernet network must be assigned its own unique IP Number. An IP address is written as four decimal numbers e.g. 192.168.1.209

ISO

International Organization for Standardisation

job

A logical "hold-all" for a group of schedules and other commands, and related data and alarms. Each job has a name and a directory structure that organizes this information. See Jobs (P23).

kB

kilobyte, 1024 bytes

kbps

kilobits per second, 1024 bps

Kelvin sense point

A particular point in a measurement circuit where a measurement should be made to ensure the best possible accuracy by ensuring that unwanted voltage drops due to current flows are minimized. Symbol

LED indicator

Light-emitting diode indicator. The *DT80* has three LEDs on the front panel, which light to indicate Sampling, Internal Disk Activity, Attention Required and Power Status.

logging

Recording or storing data. The *DT80* logs data to its internal memory and/or an external USB memory device. Logging is a separate, user-configurable operation that the *DT80* performs in addition to its basic function of data acquisition (taking measurements from sensors connected to its inputs). See also data logging system (P332) and data acquisition system (P332).

lsb

least significant bit (within a byte)

LSB

Least Significant Byte (within a multi-byte word)

mΩ

milliohm, 10^{-3} Ω

mA

milliamp, 10^{-3} A

MB

megabyte, 1048576 bytes

Mbps

Megabits per second

Modbus

A widely used control and automation communications protocol, often used in SCADA systems.

monolithic sensors

Also called **IC** (Integrated Circuit) sensors. Sensors that are constructed on a single piece of silicon using integrated circuit fabrication techniques. Available sensors include those for measuring temperature (see Temperature – AD590 Series IC Sensors (P250)), pressure, acceleration and concentration of various compounds in gases and liquids.

ms

millisecond, 10^{-3} s

msb

most significant bit (within a byte)

MSB

Most Significant Byte (within a multi-byte word)

multidrop

In communications, a multidrop configuration allows multiple devices to be connected in parallel by means of a single twisted-pair cable. This requires that each device switch off (tri-state) its transmitter when it is not actively transmitting.

multiplexer

A "many-in, one-out" switching network that allows many input signals to time-share one analog input circuit. It sequentially routes multiple channels to a single signal processing system.

NAT

Network Address Translation. A system used by TCP/IP routers to allow a small number of public IP addresses to be shared by many different devices on a private network.

noise

Unwanted voltage or current (generally with an AC component) superimposed on the wanted signal.

null-modem cable

A communications cable for connecting two DTE devices together (for example, a PC to another PC, or a *DT80* to a PC). Also known as a **crossover cable**.

nybble

Half a byte (four bits)

parse

To identify components of a command string

PC

A personal computer of the IBM or IBM-compatible type. (Although the Macintosh is technically a PC, it is not referred to as such.)

PCB

Printed Circuit Board

peak-to-peak

The value of an alternating quantity measured from its negative peak to its positive peak.

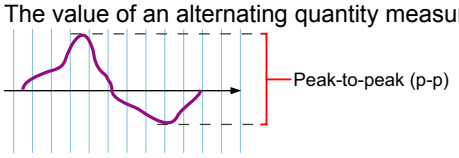


Figure 144: Peak-to-peak measurement

period

The time taken for a cyclic event to repeat itself. Reciprocal of frequency:

$$Period = \frac{1}{Frequency}$$

PLC

Programmable Logic Controller. Used to automate monitoring and control of industrial equipment.

plug-and-play

A device whose characteristics are automatically determined when it is plugged in. All USB devices are plug-and-play.

polling

Requesting information

port

A plug, socket or interface that enables connection to another device for information transfer. For example, the *DT80* has three ports for communicating with a host computer: Ethernet, USB and RS232.

port (TCP/IP)

A logical endpoint for a connection between two applications over a TCP/IP network. This allows multiple independent connections to exist over the one physical cable. For example, an application such as DeTransfer can connect to port 7700 to access the logger's command interface, and at the same time a web browser can connect to port 80 to access the logger's web interface.

PPP

Point-to-Point Protocol. A low-level protocol that allows TCP/IP based protocols to be used over an RS232 connection.

process list

The part of a schedule command that follows the schedule header and trigger, and lists the processes you want the schedule to carry out. It may include, for example, a channel list and an **IF** command.

program

A *DT80* program is a group of one or more jobs or commands that you send to the *DT80*.

protocol

The language (or set of rules) that devices use to communicate over a network. For the Information Superhighway, think of protocols as the "rules of the road". All devices on a network must use the same protocol to communicate with each other. See TCP/IP *(P337)*.

RAM

Random Access Memory. Memory that allows the storage locations within it to be accessed (written to or read from) directly (non-sequentially). This characteristic makes RAM very fast. Often simply called **memory**.

RAM disk

An area of RAM configured by a software program to emulate a disk drive.

real-time

As it happens. The *DT80* can return data directly to the host computer in real time — that is, as each scan is made, its resulting data is returned to the host computer straight away and displayed on-screen immediately.

resolution

The smallest detectable increment of measurement — that is, the smallest change in input that produces a detectable change in output. In the field of data acquisition, resolution is the number of bits that the ADC uses to represent the analog signal — the greater the resolution, the smaller the changes in input signal that can be resolved/detected.

retrieve

To unload or return data and other information from the *DT80* to the host computer, either by:

- Unloading through one of the *DT80*'s communications interfaces
- Unloading by temporarily inserting a USB memory device into the *DT80*

ROM

Read Only Memory. Memory that can be randomly read from but not normally written to. The *DT80* uses flash ROM.

RS-232

A common communications and interface standard for connecting two serial devices in a point to point configuration.

RS232 uses a negative voltage (typically –5V) to represent a logic "0" and a positive voltage (typically +5V) to represent a logic "1". These signals are with respect to a common ground terminal, hence RS232 is said to use *single-ended* signalling.

RS-422

Another communications interface standard for point to point connection of serial devices. RS-422 uses *differential* signalling (a pair of wires for each signal, no signal-ground connection) which provides improved noise immunity and allows operation over longer distances than RS-232.

RS-485

Yet another communications interface standard. Like RS-422, RS-485 uses differential signalling. RS-485 is designed for **multi-drop** operation over a single shared pair of wires. RS-485 is therefore a **half duplex** protocol –only one device can transmit at any one time.

RTD

Resistance Temperature Detector. A resistive sensor that changes resistance with changes in temperature.

sampling speed

The maximum rate at which analog-to-digital conversions can be done. This includes any channel selection time, settling time (for the signal to stabilise) and processing time (if required).

SCADA

Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control plant status and provide data logging facilities.

schedule

A collection of channel definitions which will be evaluated when a certain trigger condition is true (e.g. the required time interval has elapsed, or a digital input has changed state)

schedule header

The schedule's ID and trigger, e.g. **RA1S** — see *Figure 7* (P44).

SDI-12

Serial Data Interface – 1200 baud. A 3-wire multi-drop serial sensor interface, and associated protocol.

serial

One by one. In serial data transfer, data is sent in a single stream of bits, one bit at a time, one after the other. The opposite of serial is parallel. In parallel data transfer, several streams of bits are sent concurrently.

settling time

The time allowed for an input signal to stabilise after the *DT80* selects the channel, selects the gain, and applies excitation (if required). See channel settling time (P330).

shared-terminal inputs

Analog inputs where a common reference is used. Also called single-ended inputs. For example, the **1*V**, **1+V** and **1-V** commands all measure single-ended voltages relative to a common point (the 1# terminal)

See *Shared-Terminal Analog Inputs* (P20).

shield

A conductor surrounding input signal wires that is generally connected to the *DT80*'s ground. The purpose is to shield the input signal from capacitively-coupled electrical noise. Such a shield provides little protection from magnetically-induced noise.

stand-alone

Not connected to a host computer. The *DT80* is designed to operate in stand-alone mode: once programmed, you can disconnect the *DT80* from the host computer leaving the *DT80* operating totally independently. Later, to download data or reprogram the *DT80*, you reconnect the host computer.

state

Of an alarm: the true/false result of an alarm test.

SWFC

Software flow control (XON/XOFF). Also known as **software handshaking**. See *flow control* (P333).

A device using software flow control will stop transmitting if an XOFF character is received and will resume when an XON character is received.

switch

A two-state (ON or OFF) command that changes a *DT80* internal setting. For example, sending the switch command **/R** to the *DT80* turns ON the return-of-data-to-the-host-computer switch, and sending **/r** turns it OFF. See *Switches* (P203) for a complete listing.

syntax error

An error in the order, arrangement or spelling of the components of a command.

TCP/IP

Transmission Control Protocol / Internet Protocol. A commonly-used family of communication protocols. TCP/IP protocols are used on the *DT80*'s Ethernet interface, and can also be used on an RS232 link if PPP is enabled.

All TCP/IP protocols allow data to be transported across a local area network or the Internet.

TCP

Transmission Control Protocol. TCP is the default TCP/IP protocol used by the *DT80* to communicate over an Ethernet or PPP link.

TCP provides:

- flow control (prevents data being sent faster than it can be received)
- reliable data transfer (errors are detected and data is automatically re-sent)

- support for application protocols, such as e-mail and FTP

thermocouple

A temperature-sensing device constructed from dissimilar metals. See *Temperature – Thermocouples* (P246).

transducer

A device that converts a physical parameter (temperature, for example) into an electrical voltage or current. It is usually a sensor with additional electronics for signal conditioning and scaling.

UART

Universal Asynchronous Receiver/Transmitter. A hardware component that provides an RS232 serial interface. The *DT80* uses two UARTs – one for the host RS232 port, one for the serial sensor.

UDP

User Datagram Protocol. A component of the TCP/IP suite of protocols. UDP is a simple "connectionless" protocol that operates in a similar way to an RS232 link, except that the link can be across a LAN or the Internet.

Unlike TCP, UDP does *not* guarantee that all data will be delivered.

unshared input

a differential input.

URI

Uniform Resource Identifier. A standard way of identifying a resource (such as a file) on a TCP/IP network. The *DT80* uses a URI to specify the destination when uploading to an FTP server.

USB

Universal Serial Bus. A standard method of connecting peripheral devices to a host computer. The *DT80* operates both as a USB *device* (when talking to a host computer) and as a USB *host* (when talking to a USB memory device).

See *USB* (P162)

USB Memory Device

A memory device designed to be connected to USB. These devices can either be hard disk drives or flash memory devices. They are generally powered from the USB port.

V

volt, a unit of electrical potential (voltage)

version number

The version number of the *DT80*'s firmware consists of a major number, a minor number and a build number, e.g. for Version 6.18.0002, the major number is 6, the minor number is 18 and the build number is 2.

vibrating wire strain gauge

a sensor for measuring strain, which works by detecting changes in the resonant frequency of a steel wire as its length changes.

whitespace

The set of "blank" ASCII characters, namely ASCII character codes 9 (tab), 10 (line feed), 11 (vertical tab), 12 (form feed), 13 (carriage return) and 32 (space).

XON/XOFF

Transmitter on / transmitter off. Control characters used for software flow control (SWFC), instructing a device to start transmission (XON) and end transmission (XOFF).

YSI

Yellow Springs Instruments, a manufacturer of thermistors.

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